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Eine systematisohe Zusammenstellung der Anlagen und Verfahren der Femlenkung
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F. MULLER
remote control
SYSTEMATIC REVIEW OF METHODS AND SYSTEMS remote control
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ABSTRACT

The book attempts to comprehensively systematize telecontrolled objects. The principles of building control systems for distance and guidance methods on the target are considered. The description of projects and samples of German guided shells from the Second World War and some English and American developments in this area is given.
The book can be recommended for a certain circle of specialists in those branches of technology where remote control is applied or can be applied. It can also be recommended as a guide for students of relevant universities and all those who are interested in this promising field of technology.

Editorial Board on Military Matters Head I. G. FROLOV

FOREWORD

The widespread use of remote control in energy, industry, transport, and especially in military equipment creates an urgent need for literature on remote control.
Recently, several works have been published abroad, in which attempts have been made to generalize the extensive experience in the design and creation of control systems for shells and other unmanned objects. Among these works is the book of the German specialist F. Müller, published by the German Radar Publishing House in 1955, which is brought to the reader’s attention.
The first chapter of the book is devoted to the classification of telecontrolled objects. This classification is cumbersome and in some cases diverges from that used in our domestic literature.
The second chapter discusses the principles of building control systems and targeting methods. Many of the methods described here for generating, transmitting, and executing control signals are used in individual branches of modern technology, but especially widely in aviation and guided missiles. There is every reason to believe that the scope of these methods will multiply and expand.
The final chapter of the book, the largest in volume, contains a description of the samples and projects of German guided shells from the Second World War, as well as a list of some English and American developments in the same field. It is clear that in the vast majority of cases, the tactical and technical data of the described systems are outdated and do not meet modern requirements. Some
6 are also outdated.

principles of building systems that have become unsuitable for conditions of high speeds and altitudes. However, this chapter contains numerous useful data and characteristics, as well as guidance on the organization of scientific research and development in the relevant field.

In general, the book will be of undoubted interest to many experts.

A.A. Krsuovsky.

## AUTHOR'S PREFACE

Telecontrol is one of many areas of the new application of telecommunication technology. As in many other cases, unfortunately, in matters of telecontrol, only military equipment has been able to move from, in principle, a long time ago clear theoretical formulation of the problem to the implementation of practical projects on a large scale.

In order to review the development of this interesting field of technology, which is the task of this work, perforce, we will have to turn to the history of the development of weapons during the Second World War. But, before starting to consider specific projects, in the first part of the book an attempt is made to systematize telecontrolled objects. At the same time, no distinction was made between completed and unrealized projects.

The second part discusses the problems and methods of telecontrol. Particular attention is paid to the formulation of problems and the possibilities of solving them using electrical communication technology, while other branches of physics and technology related to the implementation of telecontrol projects are mentioned only in passing.

These comments also apply to the third part, which provides some data on some telecontrol systems created in Germany before 1945. It should be noted that at my disposal there are only a few and far from complete materials. Many of the details and data presented in the book - especially in sections 3.3 and 3.5 - are recovered from memory and therefore can only claim to be correct in their basic provisions and order of magnitude.



The attached list of literature contains, in addition to several special works and reports on the special field of technology considered here, a number of general works that are more or less closely related to the technical issues raised in this book. The text also provides many references to literature and sources.

Concerning the order of presentation of the material in the book, it should be noted that in all its sections the decimal numbering system in accordance with DIN 14211 was applied and a very wide detailing of the material was carried out. I hope this will meet my promise in the subtitle of the book. Frequent references to various sections of the book as the material is presented should serve the same purpose. I am aware that they will make reading somewhat more difficult, but at the same time they will significantly help me in systematizing the presentation of the material.
Darmstadt, Münster (Westphalia), Göttingen, 1953.
Ferdinand Müller.
1 German (industrial) standard. - Note before.
CHAPTER FIRST
SYSTEMATICS OF REMOTE CONTROL OBJECTS
1.1. BASIC concepts
The excitation of certain processes in one place as a result of issuing commands in another - because they do not serve to transmit information cleanly - is usually called remote control. If in this case we are talking about the impact on the movement of crewless objects on land, on water and in the air, then we are talking about telecontrol1. Telecontrol includes the following elements:
1.11. Issuing a team.
1.12. Command transfer.
1.13. Reception team.
1.14. Team conversion.
1.15. Execution of the team.
Section 1.11–1.13 is a special case of transmitting information for remote control purposes (for example, relays, switches, etc.), while links 1.14 and 1.15 serve to turn the team into an effect on the movement of the object (usually through various types of servomotors )
Solving problems of this type is a matter of remote control technology, one of the vast areas of electrical communication technology. Its most important means are electronic devices (for example, transmitters, receivers, amplifiers), as well as energy converters of various types (for example, light sources and photocells, microphones and telephones, motors and generators).
1 In a more general form, telecontrol is defined as remote control of any objects (moving and motionless) by means of signals whose power is much less than the power of controlled processes. - Note ed.
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The first step in telecontrol is driving by telecontrol signals [54p, in which the controlled object has a crew and the transformation of the received command into moving the governing body occurs with the help of the human brain and hands. Similar methods will not be considered here. If the transmission of the command is “short-circuited”, that is, the places of formation of the command and its execution coincide in the telecontrol object, then they talk about autonomous control. It can be, depending on the perfection of the method, either the initial stage, or the further development of the telecontrol itself. In view of this close relationship, autonomous management will also receive attention in the subsequent presentation of the material.
Studying management processes in detail, it is necessary in strict sequence to consider:
1. What needs to be managed? (Types of telecontrolled objects, section 1.2.)
2. Where and where should the object be directed to? (Trajectories of telecontrolled objects, section 1.3.)
3. How can an object be controlled? (Telecontrol technique, chapter 2.)
In addition to the control itself, it is necessary to consider in connection with it the

issue of obtaining initial data for setting control commands. It reduces in general to solving the problem of determining coordinates. (Methods for determining coordinates, Section 2.4.) Finally, it is necessary to find out what will happen to the telecontrolled object or what should happen to it when it reaches its goal or passes by it. (Execution of special commands, section 2.6.)

## 1.2. TYPES OF CONTROLLED OBJECTS

In principle, any object capable of moving in space can be telecontrolled. Telecontrol methods and the arrangement of equipment necessary in each individual case depend on many factors,

1 The square number in parentheses indicates the number of the source according to the literature index placed at the end of the book.

The systematics of telecontrolled objects is the 11

most important of which will be considered in this and subsequent sections of the first chapter. As with any classification, there are also various granularity options. The system adopted for this purpose should primarily indicate the diversity in the statement of the problem that may occur in solving telecontrol problems.

First of all, it is necessary to distinguish between controlled objects that serve only to transport the “carrier of action”, after which they are either destroyed or delivered to a specific place, and those objects that directly themselves have the desired effect on the target. From this follows approximately the following classification.

1.21. Managed carriers of special instruments and equipment (if we are talking about combat missions - see the preface, then “instruments and means” can be weapons):

1.211. With return or with “landing” in a place previously appointed or selected by remote control.

1.212. Without return, that is, without the intended landing.

This refers to any means of transportation (by land, by water, in air and in interplanetary space) in their usual sense.

1.22. Managed “action carriers” that is, objects that not only carry devices and other means, but must themselves perform a specific task on the target.
There is another type of telecontrolled objects, the purpose of which is only to move along a predetermined path - these are models of land and water transport vehicles of all types. They can almost be attributed to controlled instrument carriers if you do not take into account the absence of a payload. The named types of managed objects are discussed in more detail below. The given examples of the goals of the Application and the forms of execution should - here, as in the following sections, without claiming completeness - indicate only a few possibilities.
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1.21. Managed media of special devices and tools
1.211. With return or landing.
1.211.1. For n obleudin and I. These include the following applications: making measurements in places where the use of human-driven vehicles would be fraught with great risks for the latter or in the case where the equipment of the vehicle with remote control is more economical than using observers; specifically:
making measurements in areas of radioactive contamination;
study of the ionosphere and high-altitude flows (high-altitude rockets); exploration of the deep sea; meteorological observations; performing intelligence tasks using television, infrared and other cameras.
In accordance with the task, the observation results (measured value, snapshot) can be recorded on board the instrument carrier or transmitted via a communication line to the launch site or to another place.
1.211.2. For the delivery of weapons: explosive charges (remote-controlled tanks); mines (remote-controlled vessels); bombs, mines, leaflets, marker beacons, etc. (remote-controlled aircraft), shells or missiles (remote-controlled objects of all kinds). This also includes the transportation of structural parts and instruments of all types to other celestial bodies, including artificial satellites (interplanetary stations); for spaceships with a crew, it is also necessary to provide remote control or autonomous control at least for the period of acceleration after launch and, depending on the circumstances, for the period of braking before landing.
1.211.3. As target layouts. This includes moving targets of all types, such as models of tanks, target ships, target aircraft, ships and target towing aircraft.
The systematics of telecontrolled
objects_13 1.211.4. Models of land and water transport vehicles of all types (see above). In category 1.211 (with return or landing), it should also be distinguished whether the managed object is returning to its starting point, whether it is landing (mooring) in another predetermined place, or it must be brought by remote control to any other place.
1.212. No return or landing provided.
1.212.1. For observation. If, as in the examples given in 1.211.1, a television transmission of the measured values or images to an intelligence point is provided, then the return of the instrument carrier is not necessary. But the transition to a one-time action, to objects without landing, is usually carried out only when landing of a telecontrolled object is impossible for technical or organizational reasons, is expensive, or is not guaranteed. For example, in the case of reconnaissance of enemy territory with a high probability of destruction of controlled surveillance equipment, with limited range due to insufficient fuel supply, in the case of using unmanned high-altitude missiles. It should be recalled that it is possible to drop measuring or recording devices by parachute, while the object itself (for example, a rocket) disappears.
1.212.2. For the delivery of weapons. The considerations set out in section 1.212.1 are valid here. You can only add that the payload, if you refuse to return the managed

object, can be increased due to fuel. These include interplanetary ships, which should, for example, deliver only signaling means to other celestial bodies (the first lunar rocket). This could also include resettable launch boosters and lower stages of composite missiles.
1.212.3. As target layouts.
Moving targets in case of their destruction due to hit.

1.22. Managed weapons
1.221. Combat vehicles: tanks, ships, planes, etc., which should, as a whole, cause the desired effect.
1.221.1. Carriers of explosive charges, for example landmines, launch boats, missile planes, intercept missiles.
1.221.2. Objects that create a false effect and radio interference, such as models of submarines, aircraft with jamming transmitters. They usually have their own engine.
1.222. Dumped bodies. These include: falling bombs, gliding bombs (high-explosive, mine bombs, supply bombs); torpedo planes (surface, underwater). These objects can be:

1.222.1. Without its own engine.
1.222.2. With own engine.
1.223. Shells:
1.223.1. Without its own engine (artillery shells).
1.223.2. With its own engine (missiles of all types, torpedoes).
Tab. 1 gives a generalization of the classification given in Section 1.2.
Table 1
TELEVISIBLE OBJECTS
Managed instrument carriers Managed weapons
with return without return
Obs with telecast data or with data broadcast Charge carriers, objects of false effect
Resetting weapons Destroyed bodies
Dummy without destruction of I targets with destruction due to hit Shells without their own engine and with their own engine
Models
Other

1.3. TRAJECTORIES OF REMOTE CONTROLLED OBJECTS
If the classification given in Section 1.2 is based on the distinction of telecontrolled objects by the purpose of their application, then their classification according to their motion paths will be given here. Again, for each of the many cases, individual application examples could be given; however, it is only important to identify the main features that will allow us to classify certain objects. First of all, you can distinguish:
1.31. Starting place and goals Starting
place and goals possible:
1.311. On the ground.
1.312. On the water.
1.313. In the air.
1.314. In interplanetary space.
This already gives 16 categories of objects, and individual objects can be used to hit different targets or have different launch sites (for example, remote-controlled bombs can be used to hit targets on land and on water). The number of theoretically possible combinations will increase to 25, if we further distinguish between the start or target:
1.312.1. On the water.
1.312.2. Under the water.
1.314. In interplanetary space. Some of them are presented graphically in Fig. 1, and the first digit according to the scheme adopted above means the starting place, and the second - the target location.
1.32. Trajectory
In addition to the differences in the place of launch and the goal, one can also make a difference in the trajectory of the telecontrolled object from start to target. So, for example, a ground target can be reached from land (1–1) when an object moves:

1. On the surface of the earth with the help of ground-based telecontrol machines (1–1–1).
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3-3
ti
\ li
"'K I kA
S' / z-3
\ f /
K '' '2.1-i A! /' '' N22-21 '1'

tvV \ Va \\ 4 \ v ^ V ^ VAVXVW ^^?
P and p. 1. Some possible options for the start and purpose of telecontrolled objects
2. On the water surface lying between the start and target using telecontrolled amphibians (1-2—1).
^ = A
3-2.1 /
and / />)
,
w / / k h
/ the V // / -?
Do
I
Figure. 2. Aerial attack capabilities of a marine target.
TB - telecontrol bombs; TRS - remote-controlled rockets; TPB - remote-controlled planning bombs;
TPBV - remote-controlled planning bombs with immersion in water; TT (n) - remote-controlled torpedoes (surface);
TT (c) - remote-controlled torpedoes (underwater).
3. By air using remote-controlled shells
Systematics of remote-controlled
objects_17 A ship can be reached from a submarine (2.2—2):
2.1. On the surface of the water when the submarine is in the surface position (2.2-2.1-2.1).
2.2. Under water using a torpedo (2.2-2.2-2.2).
3. From the air with the help of rockets (2.2—
3-2.1).
In fig. Figure 2 also shows examples of an attack by a sea target from an airplane (3.2).
A summary of the described features is given in table. 2. In addition to the starting point and delhi, one can also indicate various types of start as an important feature that distinguishes objects.
1.33. Start type
Depending on the type of special object, the start is carried out as:
1.331. Departure
1.332. Takeoff.
1.333. Reset
1.334. Shot.
Further, the start can be divided into:
1.331.1. Free, that is, without giving the start-up facility a special direction.
1.331.2. Directional (guiding paths: rails, runners, pipes).
1.332.1. Without an additional starting engine,
1.332.2. With an additional starting engine (starting carriage engines, resettable auxiliary rocket engines, etc.).
1.34. Type of goals
1.341. Areal.
1.342. Spot:
1.342.1. Motionless.
1.342.2. Moving (here the speed of movement and the maneuverability of the target play a significant role).
Depending on the type of long-distance object (1.2), the starting place and the type and purpose of the trajectory (1 3) pred-
2 Telecontrol
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are different management requirements with regard to its method, accuracy, cost,

etc. However, before considering the very methods of control, you need to make some comments about the mechanics of control.
Table 2 trajectories of telecontrol objects
Goal \ Start TpiuV ect- \ rya \ 1. On the earth 2. In the water 3. In the air 4. In the interplanetary space
above the water under the water
1. Ground On the earth In the water Ground vehicles of Amphibian Amphibian Amphibian, burial -> Managed under WATER Managed objects dumped to the ground. Discharged amphibians -
In the air In the interplanetary Aircraft, shells Aircraft, shells Missiles Aerial bombs, art. Shells> Missiles

space Interplanetary rockets
2. In the water On the earth In the water / Amphi-f bii Coralli, torpedoes Submarines -
-
2.1. (Above water) In the air In the interplanetary space Aerial bombs, shells Shells Runets Aerial bombs, shells | Rocket
Systematics, remote-controlled objects 19
\ Start 2. In water 3. In air 4. In interplanetary space
Purpose Tra ^ H ecto- N. riya N On the earth above water under water
On the earth 1 Amphi-Gbii, (immersion - _ Torpedoes I De-
2. In water 2.2. In water) living under water Submarines, | bin ^ bombs, planes, (Underwater) In the air In the interplanetary space (Tor-1 pedals Torpedoes - torpedoes
3. Aerial On the ground In water - - -
In the air In Aircraft, shells Aircraft, shells | Missiles
Aircraft , shells of interplanetary space
4. In interplanetary On land - - -
space In water In air In ~ -
interplanetary space> Missiles Missiles Missiles Missiles Missiles
2 *
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Chapter 1
1.4. MECHANICS OF REMOTE CONTROL
1.41. Scope of control
Depending on whether the telecontrolled object moves on land, on water or under water, in air or in interplanetary space, the number of its degrees of freedom is determined. It is 1: 1.411
. For land and water bodies ... 2
1.412. For underwater, air and interplanetary objects .............. 3.
If we consider translational movement in the “longitudinal” direction as one degree of freedom (you can act by changing the speed of movement, see 1.421), then for control itself it remains:
one plane (left – right) for ground and surface objects (1.411);
two planes (left – right and up – down2) for underwater, air and interplanetary objects (1.412).
In the polar coordinate system, this means for the former rotation (1.411) around a vertical axis, for the latter (1.412), rotation around two axes:
1.412.1. Or around the vertical and transverse axes ("control in the Cartesian coordinate system").
1.412.2. Or around the longitudinal and transverse or longitudinal and vertical axes ("control in the polar coordinate system"). In the table. 3 gives a comparison of these distinctive features.
1 This refers only to the degrees of freedom of translational movement in space, which are of primary interest for control, while the degrees of freedom of rotation around three axes are a means to change the state of motion. Rotational degrees of freedom must be taken into account when, in addition to influencing the translational motion mode, it is also necessary to influence the position of the object in space. This occurs when the object must stabilize, for example, relative to the longitudinal axis, so that the spatial obedience to control commands with respect to the other two axes is maintained (see 2.23 and examples 3.522 and 3.523.1).
2 Here, as in table. 3, it is assumed that the horizontal translational movement of the telecontrolled object is mainly horizontal. In vertical movement, instead of “up-down”, the direction “forward-backward” is accepted if the observer is outside a moving object. In interplanetary space, these designations lose their meaning and can only be attributed to the axes of the object.

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Table 3
CONTROL VOLUMES
Remote-controlled objects Above-ground, underwater, underwater, interplanetary
Degrees of freedom 2 3
Control planes 2
Direction left - right left - right up - down
Cartesian vertical axis vertical axis transverse axis
Control the polar longitudinal axis transverse axis
vertical axis longitudinal axis
After the foregoing, it becomes clear that the cost of remote control of objects in 1.412 (underwater, air and interplanetary) is always greater than for control of objects in 1.411 (ground, surface), since for the first need to transmit - simultaneously or sequentially - a larger number of teams.
1.42. Ways of influencing movement.
Ways of transforming a command received by a telecontrol object into an effect on movement (execution of command 1.15) can be extremely diverse. The purpose of this book is not to examine in detail these mechanics issues. Here, within the framework of the "systematics" of this section, only a cursory generalization of the possibilities of accomplishing tasks related to telecontrol will be given.
1.421. Drive bodies. The impact on the speed of translational motion (in the direction of the longitudinal axis) is almost always carried out by controlling the engine or applying the brakes. In the table. 4 shows the main features. In its lower part, it provides an overview of (1.422) controls, ie means of influencing the movement in the direction
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niyah perpendicular to the direction dvizheniya1. When considering the table. 4 it becomes clear that the governing bodies related to them in relation to the functions performed, costs, accuracy, amount of energy consumed, etc. are extremely diverse.
1.423. Executive bodies. The auxiliary means used to actuate the drive control or control organs, by their design, depend so much on the characteristics of the corresponding telecontrolled object that a review can only be given here in the form of a listing of the main features. Considering the table. 4, we can come to approximately the following classification:

1.423.1. Opening and closing valves, etc.: for steam engines 1.421.21
for internal combustion engines 1.421.22 in connection with the regulation of energy supply 1.421.31 in connection with braking of the counter drive 1.421.44 in connection with the control of the caterpillar system (two-way drive control )
1.422.22
in connection with the control by means of other combined drives 1.422.31 for jet engines 1.421.24 in connection with the regulation of energy supply 1.421.31 in connection with the inclusion of additional
nozzles 1.421.34
due to braking of the anti-engine 1.421.44 in connection with control with help of the composite engine 1.422.31 due to the inclusion of additional
nozzles 1.422.33
when controlled by flooding 1.422.51
1 From the point of view of mechanics, there is no fundamental difference between the action of the drive and the control. In both cases, we are talking about accelerations (positive or negative) that are communicated to a moving
object. However, the fact that this is a common, used division from a technical point of view is justified, it can be seen from table. 4.
Table 4
* An air-jet engine means a liquid-propellant jet engine using atmospheric air as an oxidizing agent, as opposed to a liquid-propellant engine with an oxidizing agent on board an aircraft.
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when controlling by changing the position of the center of gravity due to fluid transfer, as well as in all cases of using hydraulic or pneumatic servomotors 1.422.52
1.423.2. Actuation of switches or electrical control elements (resistances, etc.):
for diesel-electric engines 1.421.224 for purely electric engines 1.421.23 in connection with the regulation of supply (electrical energy) 1.421.31 with electric braking 1.421.44 in connection with the tracked control system 1.422.22 when controlled by other combined drives 1.422.31 when controlled by inertia bodies (creating torque), as well as in all other cases when using electric or electromagnetic servomotors ditch or other electrical switches 1.422.62
1.423.3. Rearrangement of mechanical structural elements when controlling the drive:
by means of a transmission mechanism 1.421.32 by changing the gear ratio between the engine and the energy consumer 1.421.1 by changing the installation of the screw 1.421.33 using brakes 1.422.1 using wheel brakes 1.421.41 by braking on the ground 1.421.42 by releasing resistance surfaces (e.g. air brakes) 1.421 43 with arrow control 1.422.1 when controlling the steering axle 1.422.21 with track control with a common drive 1.422.22 by opening -toxic actuator (screw, nozzles) 1.422.32 when operating with the elevators and so on. d. 1.422.4
Systematics remote controlled object
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at the center of gravity displaced by
the movement of solid masses 1.422.52
by rotating gyroscopes or bodies around the gyroscope (moreover, the permutation can occur with the help of power batteries or servomotors of all types) 1.422.61
The fact that these differences are not sharp follows even from the fact that the valves, for example, being mechanical elements, are controlled using electricity. To indicate the variety of possibilities, we list the various ways of electric drive of mechanical valves:
1.423.11. Using an electric motor.
1.423.12. Using an electromagnet.

1.423.13. By electric ignition of the squib. While in the first two cases continuous regulation is possible, in the case of 1.423.13 it is usually only possible to open or close the valve. This difference is another important feature for the classification of executive bodies (see the continuous management and management of the yes-no type (2.31, Fig. 10)).

If we collect all the literature in which these questions are exhaustively examined, then a whole library would be compiled. Indeed, a long way has been made from a rubber motor for driving rudders of remote-controlled aircraft models to steering machines “Tserin-gen” or multi-engine transoceanic aircraft.

1.43. Control accuracy

The requirements that must be imposed on the accuracy of telecontrol depend on the type, trajectory, and in particular on the speed of the controlled object. The boundaries of achievable accuracy are determined by the overall accuracy of determining the location of the object (absolutely or relatively).

The faster the object moves remotely controlled, the less amount of time to execute the commands from the remote control date of issuance until ispol-

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Chapter 1

knowledge, and the higher are the requirements for control accuracy and for determining the location of a telecontrolled object. For example, the remote control of a large, slowly moving surface ship makes significantly less demands on the accuracy and speed of execution of control signals than the remote control of a projectile, which should hit a moving target with a total flight duration of several seconds.

In connection with the foregoing, we must also mention the range of communication in telecontrol. Along with other factors, it determines, among other things, the choice of transmission type, frequency, etc. (see section 2.7).
The variety of provisions expressed here indicates that the constructive forms of telecontrol systems can be extremely diverse. These systems use the scientific achievements of almost all branches of physics and technology. Their mutual connection often poses a very complex, but interesting task. In the following sections of the book, it is now necessary to give an overview of the technical problems of electrical communication in the form in which they arise in telecontrol technology.

CHAPTER TWO

TECHNOLOGY OF REMOTE CONTROL

2.1. MANAGEMENT TYPES

In order to direct an unmanned1 object to a specific target or make it move along a certain trajectory, there are basically (in addition to uncontrolled movement) three possibilities, which are shown schematically in Fig. 3 [52].
Shch transmission line 2.11 Stand-alone
signals of tele-v control
control
2.12 Tele- control Control
point
^
---- 2.13 Homing of an
object with a target Purpose Managed object
? Msh, Issue Execution of
4222 commands of the command
P and s. 3. Types of management.

2.11. Autonomous control

The controlled object does not experience any external influences (except for gravity and resistance of the medium in which it moves). In the object itself there are means that influence its movement in such a way that it follows a certain flight program. The necessary “control commands” (see 1.1) arise exclusively in case of deviation of the object
1 See 1.211.2.
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Chapter 2
of the predefined flight program values (heading, altitude, speed). Autonomous control is also called inertial control, and in some cases “stabilization” 1. It will be briefly described in section 2.2.

2.12. Actually telecontrol

The controlled object executes the commands given through the communication line (telecontrol line) from the control point spatially separated from the moving object. The methods used for this are discussed in detail in Section 2.3.
In order to be able to form the “correct”, that is, satisfying the telecontrol goals of the team, it is necessary to determine the position of the telecontrolled object relative to the Earth coordinate system or relative to the target. Related methods are discussed in section 2.4.

2.13. Homing

The managed object has a special device (homing head) that allows it to determine its own position relative to the target or relative to other points that determine the trajectory of the object. Control signals arise due to the deviation of the direction of movement of the object (or its axis in space) from the direction specified by the coordinator of the target. Homing is, therefore, automatic control, although in the presence of influence at a distance (the connection of the object and the target). Possible methods are discussed in section 2.5.

2.14. Combined control
Various combinations of the three control methods mentioned above are possible: using telecom commands
1 Some authors distinguish between control without external intervention and control according to a program that can be changed by external commands.
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control can intervene in setting the initial values of the parameters in the autonomous control system; at the same time, we are already talking about certain forms of telecontrol (2.253 and 2.311.1). Then, throughout the entire trajectory of the object, it can be controlled by various and alternating methods; for example, an object can start with inertial control, then by means of telecontrol it can be brought to the target area and, finally, automatically aim at that target. With such combinations, the transition from one type of control to another needs special consideration. Some related issues are addressed in 2.54 and 2.75.
2.2. OFFLINE MANAGEMENT
The principle of autonomous control can be easily explained on the most famous example of its application, automatic control of the course (Fig. 4).
2.21.
Course control A course gyroscope installed in a gimbal, for example on an airplane, has on its horizontal frame A contact K, which slides along the ring O with two contact half rings 0 (l) and 0 (p). Ring O is fixed motionless on the plane. If the plane (and therefore the ring O) rotates around its vertical axis (for example, clockwise), while „,„ as the axis of the gyroscope maintains its mathematical direction in space with an off-course,
variable, then contact K - 0 ( n)
closes to the right electromagnet M (n) is energized from the battery, and it results in steering movement HA
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Chapter 2 of the
board of R. Thanks to this, a torque is created and the aircraft receives a rotation to the left until the contact opens again and the steering wheel returns to its original neutral position, etc. Thus, in principle, "automatic heading control" is achieved, that is, an electromechanical device replaces a person on the way from the course gyroscope scale to rudders, where under normal conditions the participation of the pilot's eyes, brain and legs is required. In practice, such a primitive system is used very rarely, for example, to control the course models of wagons and ships [58, 59]. For precisely working systems, this discontinuous yes-no control (or black-and-white) is replaced by continuous (motley) control, in which, for example, instead of contact half rings, a PM potentiometer is used (Fig. 5).

When the contact of the potentiometer K is shifted, the control element is rearranged using any type of servomotor. But with such a system fluctuations are possible, it is unable to provide high quality regulation. To eliminate oscillations, additional devices are still necessary, which, as is known from the general control technique, must include damping elements. As an example in fig. 6 shows a diagram of a heading control installation in which the steering wheel is driven by an electro-hydraulic servomotor (gyro potentiometer - rotary solenoid - spool - working cylinder); it provides for flexible feedback between the working cylinder and the spool through the reduction cylinder, spring and leverage, as well as the introduction of a signal along the derivative (in angular velocity of rotation) using a damping gyroscope,
Thus, according to the above diagram, control is possible around the vertical axis of the aircraft.
Fig. 5. Gyro potentiometer.
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Damping gyro (Decree-turn rotary tpel) electromagnet
Elastic
reverse
link
rudder
Fig. 6. Heading control system with electro-hydraulic
servomotor and mechanical damping elements.
2.22. Autonomous control
It can be implemented from other sensors, the type of which is determined by the requirements for management requirements. For this purpose, for example, you can use:
2.221. The second gyroscope, the rotor axis of which is perpendicular to the transverse axis of the controlled object to stabilize the pitch angle.
2.222. A barometric altimeter, made in this case as a statoscope, to stabilize the altitude of
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aircraft flight above sea level. In underwater remote-controlled objects, a depth meter (water pressure) acts instead of it, which leads to the most famous and at the same time the oldest application of self-government - a dashboard.
2.223. A capacitive altimeter, radio altimeter or acoustic altimeter (echo sounder), as well as a mechanical sensor 1 (for low altitudes and low speeds) in order to maintain a constant flight altitude of the aircraft above the surface of the earth or water.
2.23. Stabilization around the longitudinal axis
If the position of the controlled object relative to the longitudinal axis of stabilization of the roll is also stabilized, then automatic control is obtained around three axes - the so-called autopilots [60, 62, 65]. In fig. 7 as an example, the general scheme of the Patin autopilot with three-wheel steering is reproduced [68]. Other examples are the V-2 control (see 3.522).
Stabilization around the longitudinal axis is often also necessary in order to (with control by the method of Cartesian coordinates, see 1.412.1 and Fig. 47, a) withstand the corresponding obedience to the control commands of the directional and longitudinal channels (see 3.523.1).
2.24. Regulation of other motion parameters
For the sake of completeness, it should also be pointed out that the automatic regulation of a number of other quantities that affect the movement of a controlled object, by its principle, can be attributed to the regulation described in the section "Autonomous control"; for example, speed control using tachometers or speed indicators as sensors, etc. 2 (For conventional autopilots, a speed meter

1 was provided, for example, for a surface torpedo BV-143 in the test phase, see 3.526.32.
a See 1.42. and a footnote on page 22.

is also used as a sensor for controlling the flight altitude, Fig. 7.)
Target direction sensor Target
motor
- Speed tube — A pressure head
I speed meter Repeater of the horizon
Horizon of the uterus p
. Switch! At | for fast alignment
Three-phase current converter
Fig. 7. Schematic diagram of the three-steering control “Patin” with a remote gyrocompass.
2.25. Variable installation of control signal sensors
In the previous considerations, we proceeded from an unchanged preset of elements that set the course, height, etc. But this setting can change. If, for example, rotate the O contact ring (Fig. 4) or the PM * potentiometer (Fig. 5) relative to the longitudinal axis


axis of the course-controlled object, then the balance in the control system will begin on a new course (Fig. 8).
-------- The longitudinal axis of the controlled object
--------- The neutral axis of the heading sensor ------- "• Target heading
Fig. 8. Change in course as a result of turning the course sensor. '
This change may be caused by:
2.251. As a function of time, rearranging, for example, the setting element1 according to a certain program from the clockwork. Application examples: V-1 software turning mechanism (3.521), V-2 longitudinal axis inclination during lifting (3.522).
2.252. Depending on the values of other operating quantities on board the remote-controlled object with the rearrangement of the master element from those measuring devices that measure these values. Example: the impact of a high-speed pressure gauge on the steering gear of an elevator in Hs-2932 (3.523.2).

2.253. Using telecommands in this case, the rearrangement of the driving elements occurs due to external influences on the communication line [58, 59]. Here we are already moving into the field of telecontrol. In other words, telecontrol itself goes along path
1 Instead of rearranging the sensors themselves, you can act on feedback elements that ensure the neutral position of the control mechanism.
2 The Hs-293 pressure head meter affects the system gain to compensate for changes in rudder efficiency. - Note ed.
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permutations of the driving elements of autonomous control devices.
2.254. By determining the coordinates on the object itself. Although control commands can be formed directly on board the controlled object, they are formed as a result of comparison with a given flight mode, and the deviation from it is established by its own coordinator: homing method (2.13, 2.412.4 and 2.5) 1.
2.3. REMOTE CONTROL The
basic scheme of telecontrol of a moving object is shown in fig. 9 [56] (see also 1.11 - 1.15). Transmission
line
Control
point Telepres
Fig. 9. The basic scheme of telecontrol.
owned
property
At the control point is a DC command sensor, the signals of which through the encoder, modulating and other devices are fed to the transmitter P. The DC command sensor and transmitter P can be, generally speaking, spatially disconnected in any way. The control room may be stationary or be on a moving object. A receiver is placed on a telecontrol facility. The signals received by him are sent to the control device SD. The latter activates the OS controls (1.42). Two fundamentally different methods can be used for telecontrol:
2.31. Remote Control Command Method
1 The reader will find here, as in many places in this work, a repetition of what has already been partially discussed. The author, however, considers such repetitions necessary in order to better understand the concepts used, as well as the differences between them and their mutual relationship.
3 *
36
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2.32, Equal Signal Zone Method 1.
The application of this or that method is closely related to the accepted method for determining the coordinates (2.4).
2.31. Method of telecontrol commands A telecontrolled
object is sent a specific command via a communication line. The task of the on-board equipment is to turn this "ready-made" command into the appropriate movement of the facility's control. You can distinguish between:
2.311. Separate commands sent to correct the corresponding movement or to initiate individual processes on board the telecontrolled object;
2.312. Continuous commands for ongoing continuous motion control.
For both types of commands, the specific execution of telecontrol devices depends on so many factors, some of which are briefly covered in section 2.7. Of particular importance is the question of how many different commands need to be transmitted simultaneously or sequentially one after another (section 1.41).
Various possible transmission lines are discussed in section 2.33. The methods given

in this section relate mainly to radio transmission lines (2.333.11), which at present are perhaps the most important form of communication. When modifying with the aim of using other transmission paths, such specific capabilities are taken into account, for example, such as the frequency range, type of modulation, etc.
Before we examine in detail the possible options for remote control systems, we turn to Fig. 10, from which one can get an idea of the “degree of subtlety” of control, that is, regarding the amount of information necessary for the desired effect on the controls [52].
1 The equal-area zone method is also called the radio-beam control method. - Note perev.
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The time is plotted on the abscissa, and the value of the command on the y-axis. If we consider rice. 10, it will become clear that the costs of the operation of continuous control systems (3) will be higher than, for example,
shm
- a) A single exposure time
? 6) Yes-no
control ii 1 liili
! And
? C ) Plus-zero-minus control
d) Stepwise
e) Smooth Fig. 10. Control types.
Continuous yes-no
control
(b). Subsequent the presentation will be sustained in the order of the indicated “degree of difficulty” of execution.
2,311. Individual teams.
2.311.1. Simple one-time team.
The simplest case is, respectively, fig. 10, a - consists in the fact that at the selected point in time a single command is issued that causes a certain process on board the telecontrolled object that cannot be canceled by the action of telecontrol signals. In principle, this case is satisfied by the circuit shown in Fig. 11.
The command sensor in this case consists of one key K, when closed, the transmitter I is turned on, due to which relay P connected to the output of the receiver is triggered. Closing the contact of relay p then causes the desired process. Example: a command to shut down the V-2 engine (see 3.522, Fig. 79). An example of application in the actual telecontrol: transition from one preset position

autonomous controls to a different position in accordance with section 2.253.
If it is necessary to increase the selectivity of the system to ensure reliability, then, for example, the signal of the transmitter P can be modulated with a low frequency (Fig. 11.6), and then the relay PP is in the form of a resonant relay or for actuating the relay between the demodulator and the anode detector of the receiver a low-pass filter is installed. Instead of low-frequency modulation, a certain pulse sequence (coding) can also be applied, for example, due to which the noise immunity is significantly increased.
a) Without modulation
6) With modulation
Fig. 11. The simplest systems for transmitting simple one-time commands.
Transition to simple yes / no control in accordance with fig. 10.6 does not mean a change in concept. It is necessary that the device connected by the relay contacts has the ability to restore its original position when the relay is disconnected. Example: control of models of wagons and ships, in which only commands are transmitted: left turn - right turn, right — left turn.
If, on the contrary, it is necessary, for example, to carry out the commands left turn - right - right turn, then it is necessary to apply plus - zero - minus the control corresponding to Fig. 10 b Such control cannot be achieved in the simple circuit shown in Fig. 11.

2.311.2. Multiple teams. You can distinguish between:
2.311.21. The transfer of various individual commands, following one after another in time, for example, to achieve control in accordance with the scheme in Fig. 10.6
2.311.22. Transmission of various individual commands for influencing different, independent of each other control elements on board a remote-controlled object.
For both purposes, the circuit shown in Fig. 12 [58, 59, 75, 78, 84].
Fig. 12. A system for transmitting multiple individual commands ("multi-channel system").
It is obtained from the circuit shown in Fig. 11.6; if on the transmitter side the required number of n generators with modulation of the signal Mod. is provided, to which on the receiver side there corresponds the same number of n tuned to the frequency D. / „Relay Pr? ... Pн, gamykanie contacts which pi ... p2 causes various processes. The "command sensors" (Ki -.- Kz keys) intended for the initiation of individual processes during the transmission of successive different unit commands must be interlocked so that only one "or-or" command is transmitted at any given time. The above mentioned plus – zero – minus control could be ensured, thus, according to the following scheme:
4- command / „or (more reliable) + command / ,,
0 command off. 0 team / 8,
- team / 2 - team D.
Since in this case the transmitter is always modulated by one frequency of a command, this modulation

can be carried out respectively at frequencies / x ... / n to full depth. On the contrary, when issuing commands independently in time, according to 2.311.22, for example, for controlling an object around several axes, the transmitter modulation depth at each frequency is set only to 1/1 of the total modulation depth, if all n keys can be closed simultaneously without interlocking. In addition, a combination of several frequencies is possible.

For the first type of transmission (commands follow one after another, see 2.311.21), there is another method with significantly lower cost of use, which is especially readily used for remote control models of self-propelled carts and vessels [57-59, 75, 78-80 , 83, 88].
With this method, called the breeding system1, the step-by-step switches2 are switched in the receiver by means of pulse-shaped transmitter commands in the receiver, the different positions of which correspond to individual commands (see the diagram in Fig. 13).
Step-by-step
switch "° manoy
/ Jn ~)?" / 2
Fig. 13. Command pulse control scheme for the selection system.
The plus-zero-minus control principle, as shown in Fig. 10c, it becomes clear from consideration of Fig. 14, where along with fig. 10, the command pulses related here are given. Four positions of the jog switch correspond to them:
position 1 of command 0 (initial position)
1 The described method of signal separation is essentially a code selection. - Note ed.
2 In simple systems, a jog switch can also be used directly to mechanically move the controls.
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Preset
Command
+! j +
- !!!!] 1! 1U
Command
pulses
J_1_I 1P III
Executed
command
+ /
2
thi
Fig. 14. Plus — zero — minus 4-step selection system control.
In such systems, the advantages associated with relative simplicity, among others, are opposed by the following disadvantages:
1) poor protection against interference as a result of the influence of extraneous pulses; this can be avoided, for example, by additional modulation;
2) the need to notice the last installation of the command; this drawback can be eliminated by providing for the step switch to return to its original position after executing a command or by issuing a command through a strictly set number of pulses from the initial position;

3) transition through other intermediate commands (see. Fig. 14); it can be excluded with slow execution of commands.
It follows that this system is applicable only for control with relatively low accuracy requirements.
So far, only intermittent control has been considered. Under certain conditions, however, the unit command system is also applicable for continuous control, and it is precisely when the multi-channel system (Fig. 12) consists of a very large number of individual channels, each of which can transmit commands of different amplitudes. As a result, it seems possible to obtain an almost continuous

step control according to fig. 10, d. This also applies to the mentioned selection system (Fig. 13), if the number of positions of the step switch is large enough and there is enough time for switching. It should be noted that the very complex control systems of the remote-controlled target ships Zeringen and Hessen of the German naval forces worked in principle according to this scheme; in this case, decade-long selectors with controlled reception of commands were used (see 3.526.21).
If there is enough time to go from one value of the command to the closest and the requirements for regulation accuracy are not high, then continuous movement of the controls can be achieved by simple means and with the help of separate "yes - no" commands, choosing the duration of the individual commands accordingly . In fig. 15 shows the rudder control circuit [56] in the form in which it is used, for example, for aircraft models. The receiver Pr is designed so that, depending on which command is given, it leaves relay P1 or relay P2 turned on (for example, resonant relays with two different resonant frequencies in accordance with Fig. 12). When the relay Pj is activated, the contact rg closes the battery B on the winding of the electromagnet of the left rotation of the steering machine RM, which, through the

screw B rotates the steering wheel until the command stops and the Ri relay opens or the steering wheel reaches its extreme position and thereby opens the limit switch. The
steering wheel remains in this extreme position until a new separate command appears.
2.312. Continuous teams. Continuous control is always applied when the requirements for command accuracy and control speed are higher than in the devices considered so far, and consists in the transition from individual commands to continuous. The name "continuous" should mean that the magnitude of the command to control the position of any organ at any time is determined by the corresponding movement of the "command sensor". If only stepwise continuous control is required (in accordance with the circuit in Fig. 10, d), then the problem can in principle be solved using multichannel systems according to the circuit shown in Fig. 12. However, it is clear that with an increase in the number of steps, the complexity of the system increases so much that it becomes unacceptable, and for continuous control, according to Fig. 10, d, this system is completely unsuitable.
As in all similar problem statements, the transmission of telecontrol commands with the possibility of continuous control of their values can be based on changes in the following values:
1) amplitude 3) phase
2) frequency 4) time
If we add the word "modulation" to each of these concepts, then immediately possible transmission line options are identified (see the introductory part, 2.31), and various combinations are possible, for example, transmission of control signals with temporary low-frequency modulation and amplitude modulation of the carrier frequency. The

design of special equipment depends on some other considerations that should be considered first.
2.312.1. Methods of regulation. In fig. 16 shows the difference in the circuit diagrams of the two
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possible ways. To clarify them, we will first proceed from the simplest type of modulation — amplitude modulation. In this case, the DC command sensor can consist of a variable resistance (potentiometer), which allows you to change the value of the low frequency voltage modulating the transmitter I in the modulator M, and the modulation depth should be proportional to the value of the command K. Then the voltage output by the DM demodulator located behind the receiver Ex, is also proportional to the value of the command K. If, as in the diagram shown in Fig. 16a, this voltage is supplied to the linear measuring device of the DUT, the movable organ of which directly or through the linear servomotor moves the control object of the OS, the problem is solved: moving the control element is proportional to the movement of the command sensor.
a) Direct regulation of
Li, I> M П
/ дп ^
ФО У
6} Closed regulation
Fig. 16. Regulation on open and closed circuit when telecontrol using continuous commands.
The second possibility (see Fig. 16, b) is to use the output voltage in order to use the engine to move the control element until the feedback device OS (in this case, a potentiometer similar to a potentiometer of the command sensor) takes up the position , similar to the position of the sensor commands DC. The executive system is the tracking system here. The feedback element of the OS can be a positional feedback of the control itself or its drive or controlled

also depends on other sensitive elements, the position of which indirectly depends on the execution of the command (for example, a gyroscope potentiometer, see section 2.2, fig. 5 and 6 and note on page 34). Which of the two systems should be applied depends on the specific control conditions, and the tracking systems have in general greater accuracy and speed in processing given commands. Consideration should be given to issues such as the use of proportional or integral control (static or astatic systems) of rigid or flexible feedbacks, positional and / or derivative feedbacks (differentiating), the introduction of additional control signals, the type of servo amplifiers used, etc. Regarding these general considerations, one could recommend the reader special literature on regulation and management [3–7, 23, 26.6, 61, 62]. We point out below the application examples given in Section 3.523; there, when using one or another type of command sensors and a telecontrol signal transmission line, in one case open-loop control ("Fritz X", 3.523.1) is used, in the other - closed control (Hs-293; 3.523.2). To control the height of the Hs-293, positional feedback from the elevators themselves was applied with adjustment depending on the pressure head, while in the transverse control, the position of the transverse axis itself (rather than the rudders!) Was used to form a positional feedback signal. In addition, for both axes, feedback was provided with the signal with respect to the time derivative, that is, the effective value of the control signal depended on the speed of the elevators or, accordingly, on the speed of rotation of the housing around the longitudinal axis. For height control, the Hs-293 used positional feedback from the elevators themselves, adjustable depending on the pressure head, while the transverse control used the position of the transverse axis itself (rather than the rudders!) To form a positional feedback signal. In addition, for both axes, feedback was provided with the signal with respect to the time derivative, that is, the effective value of the control signal depended on the speed of the elevators or, accordingly, on the speed of rotation of the housing around the longitudinal axis. To control the height of the Hs-293, positional feedback from the elevators themselves was applied with adjustment depending on the pressure head, while in the transverse control, the position of the transverse axis itself (rather than the rudders!) Was used to form a positional feedback signal. In addition, for both axes, feedback was provided with the signal with respect to the time derivative, that is, the effective value of the control signal depended on the speed of the elevators or, accordingly, on the speed of rotation of the housing around the longitudinal axis.

The issues discussed in this section mainly related to the electromechanical connection between the receiver and the controls. When designing telecontrolled objects, in addition to this, it is necessary to solve a large number of purely mechanical (as well as physiological.) Issues that cannot be considered here. As an example, The above-

pull the model tests conducted by the German Research Institute for Gliding, which were intended to clarify the question, at what the regulation - on the corner of the angular velocity or angular acceleration or any combination thereof can expect the highest probability that the remote-controlled bombs [ 34-36].

2.312.2. Type of modulation. Already in the introduction to 2.312, it was noted that, in principle, there are four possibilities to transmit a time-varying command, characterized by the so-called "command value", in accordance with the ordinate value in Fig. 10.5. To simplify the consideration of the issue, let us leave aside the modulation of the signal at a high carrier frequency, and let us take the case of a wired communication line with a low frequency as a basis (2.332.22). Then the circuit of fig. 16 is simplified and converted into a circuit, which is shown in Fig. 17.

Fig. 17. Assignment of commands and regulation on a low-frequency wire

communication line.
If we take into account the four above-mentioned features, which allow us to express the value of the K command, then we get the summarized in table. 5 most important options for the execution of command sensors and measuring devices for open loop control.
The feedback element of the OS with closed control (column 5 in Table 5) is generally identical to the command sensor, except for the case of time modulation, in which the signal is converted at the receiver output, for example, to the voltage allocated to remote control technology
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Table 5
MODULATION POSSIBILITIES FOR CONTINUOUS
COMMANDS
Variable value Command sensor Measuring device (for non-closed »regulation) The required number of frequencies Closed regulation according to the scheme, rns. 17 1
1 2 3 4 5
Amplitude Resistance Voltage meter 1 18 a
Frequency Capacitor. Inductance. Resistance in a relaxation generator. Variable reactance electronic tubes Frequency meter. Frequency discriminator 1 or 2 18 b
Phase Phase shifter + phase modulator Phasometer 3 18 v
Time Mechanical sensor. Relay sensor Multivibrator. Fig. 24 Relays (or periodically moving control) 1 or 2 19 ---- 23
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resistance (2.312.24). In fig. 18 are depicted in order to explain the practical schemes of closed control circuit diagrams of the first three systems [58, 59, 78].
VZZ
111 = V0 + Kth
const.
Control point (transmitter)
j line I transmission
S__
CP
DK
f = f0 + mt
FM, -,
__i w '
~ I UstasShga by playing
_ SE "~ t
1 qk

a) Amplitude modulation, 0y
The
O
oc
N
remote-controlled object (receiver)
?) OS Frequency modulation "I ----- ----- * # 0y
\ A
discriminant
minator '
in) operating phase modulation
w, \"
the *
J-

>
ph,
/ nnLm ... ^ Phage Filters discriminators
FDg
Arrange
: Phase-
shift theory
of the
opamp
(ps-tpe = tp0 + K - & (p
qps-control (times phv-reference phase
(m)
Fig. 18. Possible versions tracking control systems.

2.312.21 Amplitude Modulation 1. When controlling the amplitude1, according to the scheme in Fig. 18a (see the example in 2.312.1), the voltage divider serves as a sensor for DC commands, so the value of the low-frequency voltage supplied to the "receiver" (shown in Fig. 18 as an amplifier) depends on the value of command K. If the output receiver voltage,

1 refers to a simple change in the transfer of value should be stressed again that there is a "modulation" - in this case the voltage of low frequency - depending on the value of K. team situation is somewhat different from the types of modulation are discussed below high peredatch Cove, light sources, and so on. n.



rectified with rectifier B, lead to one terminal of the DC motor M, and connect its other terminal through the feedback feedback potentiometer to the DC voltage, then the sides and speed of the motor are determined by the potential difference between points a and b. The engine, rotating, moves the op-amp control and simultaneously the OS feedback potentiometer slider until the voltage between the points a, b, becomes zero, that is, until the command is executed. It is easy to see that an exact match in the provisions of the DC and OS takes place only if the established amplitude ratio is guaranteed throughout the entire control process, that is, the voltage of the transmitter, the resistance of the wires, the gain, the rectification effect and the comparison voltage are constant and exactly match the set values. Since in practice the fulfillment of these conditions is associated with great difficulties, the amplitude modulation in telecontrol is usually used only with moderate accuracy requirements. We add to the above that nothing will change if the engine is controlled not directly, but through a relay.

2.312.22. Frequency modulation. When controlling the frequency, the amplitude ratios do not have any effect on the accuracy of the command, since sufficient power is provided at the output of the receiver. In presented on fig. 18, b, the capacitor C serves as the command sensor, to which the trimmer capacitor Ci corresponds as a feedback element to the receiver side.

Here, as an example, motor control using a polarized relay is shown, which, when triggered, closes the upper or lower contact, depending on whether the signal frequency of the discriminator tuning frequency is higher or lower. Since the conventional circuits due multiloop discriminators such adjustment is somewhat complex, may also be available in the receiver oscillator (oscillator) configure so that its frequency corresponds to "transmit" frequency, where one





temporarily transferred to the second frequency; thus, the discriminator remains constantly tuned to the difference frequency (superheterodyne principle).

Instead of capacitance, you can, of course, use inductances to tune and fine-tune. If the sound frequency generator is a relaxation generator, then a combination of resistances can be used as a sensor. Finally, for frequency modulation at high frequencies, there is another possibility - the use of electron tubes with variable reactance when the voltage across the grid changes.

2.312.23. Phase modulation. In fig. 18.6 a command transmission scheme is reproduced, in which the command value itself is contained in the phase difference of two low-frequency voltages, the frequency of both voltages being the same / 0. To transmit such a command to a distance, two additional auxiliary frequencies are required, of which one D is modulated by the frequency / 0 and transmits the reference phase, and the other / 2 - the control phase. In this case, a phase shift device of any type serves as a command sensor and feedback element. Obviously, the costs of implementing this scheme are significant, although it seems possible to obtain

good control accuracy [58, 59]. It should be borne in mind that for the simultaneous transmission of many commands (2.312.3), only two auxiliary carrier frequencies are needed.
2.312.24. Temporary modulation. The most common method for accurately transmitting a continuous command in telecontrol technology is that the value of the command is transmitted by a signal modulated in a certain way over time. In this case, we are always talking about the periodic manipulation of any electrical quantity, and in principle it makes no difference whether the direct current, voltage of low or high frequency are manipulated. It goes without saying that the period of manipulation should be chosen so that the rearrangement of the control body can occur at the required speed. The principle becomes clear as a result of consideration of Fig. 19, authorizing the simplest circuit, wherein the low frequency again assumed Li-
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communication [52]. The ACG generator is connected to the transmission line through the command contact of the QC, which periodically closes and opens as shown in Fig. 20 a. At the end of the line through

Fig. 19. Transmission of a long-term command with temporary modulation.
Rectifier B is connected to relay P (if necessary, the signal amplifier is also switched on). The relay contact R, switching in the same rhythm as the KK command key, alternately connects to battery B, for example, two electromagnets E1 and E2, as a result of which the op-amp control element in Fig. 19, and presented in the form of a rudder - periodically turns in one direction or another. If the switching period is chosen correctly, taking into account the inertia of the telecontrolled object, then the effective action of the rudders (averaged over many periods) depends on the ratio of the time of the closed Tu and the open T% position of the command key KK. It remains to be determined what to consider as a “team value”. It is advisable to symmetric manipulation ("on-off"), in which the effective action of the rudders is zero,
(a)
Point \ control line of the transmission
b-T, t, - t.
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which can vary within the range −1 </ (t -} - 1; moreover, K = - 1, for example, corresponds to the position of the steering wheel to the left, and K = + 1 - to the right of the rudder. One could also introduce the following definition:
K 'O33K' <oo,
^ 2
however it is less obvious.
An example of the application of this type of control with time modulation (see Fig. 19, a - open a scheme with a direct effect on the opamp) is the telecontrol of the falling Fritz-X bomb. See section 3.523.1 and [97], as well as [58, 59, 74, 78, 82].
Instead of switching „on - off ”(“ yes - no ”system) of only one frequency, you can also alternately switch two different frequencies D and / 2, thereby significantly reducing the effect of interference. In this case, one of the types of “plus - minus” inclusions in the systems that correspond to Fig. 12 (with n = 2). In practice, further, the wire line is usually not connected directly to the command key of the QC, and between them the amplifier of the UE transmitter is turned on; In this case, a system corresponding to Fig. 19, b (see also 3.511.22 and Fig. 50, 51). This diagram shows a different type of control: instead of directly turning on the electromagnets of the rudders, as is the case in the diagram of Fig. 19, a, here P includes a servomotor M, which moves the object control movement of the object of the OS. Since a feedback device is not provided here, then the engine (at K ^ .0) rotates in one or the other direction with a speed corresponding to the absolute value of the command value (the so-called integral or astatic system). With this type of regulation, proportional or static control can also be obtained if, instead of the motor, an actuator is used in the form of a rotary magnet with a spring and a damping device. The switching scheme related here is shown in Fig. 20 b To complete the picture in fig. 20c, another possibility of time modulation is presented - pulse phase With this type of regulation, proportional or static control can also be obtained if, instead of the motor, an actuator is used in the form of a rotary magnet with a spring and a damping device. The switching scheme related here is shown in Fig. 20 b To complete the picture in fig. 20c, another possibility of time modulation is presented - pulse phase With this type of regulation, proportional or static control can also be obtained if, instead of the motor, an actuator is used in the form of a rotary magnet with a spring and a damping device. The switching scheme related here is shown in Fig. 20 b To complete the picture in fig. 20c, another possibility of time modulation is presented - pulse phase
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53th
modulation (in Fig. 20, a shows the modulation of pulses by duration) as it is used as the latest method for high-frequency manipulation (2.312.3).

a) Single-frequency system (, $ a-no ”) -modulation by long pulses
6} Two-frequency cucmeMaQwtoc-minus”)
c) Pulse phase modulation
Fig. 20. The possibilities of temporal modulation.
While in fig. 19, b, in accordance with the classification (2.312.1), examples of an open actuator are given, Fig. 22 illustrates the principle of closed control using feedback, and only the output of the receiver is presented (the circuit can be supplemented by the left side of Fig. 19, b). The feedback element is a resistance, the slider of which is moved by the drive motor of the OS control element (positional feedback).
In a simple system corresponding to the circuit depicted in Fig. 22a, it is achieved that the average position of the drive corresponds to the average value of the DC signal (integral of the manipulation curve, see the dashed line in Fig. 21), which in turn corresponds to the value of the K command. The servomotor oscillates around this middle position. The inertia of the servomotor and other factors can lead to a certain deviation from symmetry and are identical in magnitude, but different in sign K can cause, to a certain extent, deviations of control elements in magnitude.
In order to obtain a symmetrical shifting of the servomotor in steady state, it is possible to use the executive system in the form as presented on
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fig. 22b (the regulation principle adopted in the management of Hs-293, see 3.523.2 and Fig. 90). The control signal from the relay contact Pj enters the filter, at the output of which a voltage appears, consisting of the average component:
1
- K
I
±
2
k = 1l1a = A o
lt 2
k '= Ll = - 1 s
p t2 3
Fig. 21. The value of the command in time modulation.
which is proportional to the value of the K command and the alternating component of the
the
frequency voltage i superimposed on it (see Fig. 23). DC motor M,

driving OU management body is connected to the terminal P2 alternately forward or reverse
in
a) servomotor varies asymmetrically
Fig. 22. Connecting a periodic continuous command to a static servo control circuit.
power supply voltage. Polarized relay work now depends on the position of the reverse cell
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communication OS. If we assume that the slider of the feedback OS potentiometer is in the initial position in the middle position, then relay P2 vibrates asymmetrically and the motor moves the op-amp, which means the OS until
until the voltage at point t becomes equal to the average value of the voltage between the whigs; after this, p2 vibrates symmetrically and the motor oscillates symmetrically with respect to its average position corresponding to the value K.
In the case of L / C filters used previously in practice (according to Fig. 23, a), high filter costs were obtained at low manipulation frequencies (10 ni) (large inductances and capacitance). Using the method described in the studies of M. Markuardt, one can achieve the same effect as in L / C filters (and in the presence of higher harmonics, even better), if the resonant circuit tuned to the fundamental frequency is replaced with a simple B / C filter. Here we proceed to consider the circuit in Fig. 23b, noting that in this scheme the feedback element is a double
J-
6) The servo motor in the steady state oscillates symmetrically
Fig. 22a.
c) The servomotor in steady state is at rest
Fig. 226.
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a) With an L / C filter and one 6) With an R / C filter and a double potentiometer, the potentiometer
I - 1-I-si-Pr
^ TfTIHimw ^ тпшт
^ dммшнпину? Jnnnninnni
Pi
Ua
ut
And "
ив- and, -
* 2 (id-ig)
Pr
Pi
Fig. 23. Tracking systems with filters on.
potentiometer. (The curves of the voltage change in time shown in Fig. 23b are actually composed of sections of the exponents, which are shown in the plots of the
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replaced by straight lines.) This type of regulation has also been successfully applied on the Hs-293.
Possible additional voltages (for example, a damping signal) can be introduced at point t (Fig. 22, b, cf. Fig. 90). With this control method, the range of command values is limited so that there is still a sufficient variable voltage component. In practice, they proceed from approximately values of –0.9 +0.9. Here, the feedback sensor can

also be rearranged not only by the drive of the control body, but also by measuring the position of the object; Example: lateral control of the HB-293 (see 3.523.2).
If it is necessary to bring the rudder drive motor as quickly as possible to the set position and turn it off when this position is reached, then you can go along the regulation path, according to fig. 22, in [76]. The output voltage of the receiver is supplied to rectifiers Bi and B2, which charge the capacitors Ci and C2. The voltage distribution between them then directly depends on the time distribution of D and / 2, that is, on the value of the K? This, as well as the position of the slider of the feedback feedback potentiometer, determines the voltage on the lamp grid, and hence the anode current. The number of ampere turns of any of the two windings of a polarized relay depends on the latter. The relay is arranged so that with a symmetric command (K = 0), the contact of the relay p takes a middle position if the OS slider is in the middle of the potentiometer.
It remains to consider how the command sensor, the so-called KK command key (Fig. 19) can be designed to achieve a continuous change in the ratio of the time of the closed and open state of the contacts. There are basically three possibilities for this, which are to apply:
a) mechanical devices;
b) relay devices;
c) electronic devices (multivibrators), which are schematically shown in Fig. 24.
Fig. 24. Examples of switching command sensors.
Other examples of the execution of mechanical command sensors are presented in Fig. 46. Another method is given in section 3.511.14. In electronic devices [76, 100], mechanical relays are usually not used, but multivibrators are used to lock and unlock signals of the corresponding frequencies (for example, using diodes). In the same way, a shift of pulses can be produced during pulsed phase modulation (see Fig. 20, c and 25, as well as [77, 90, 110]).
It should also be noted that time-modulated long-term continuous commands can be used to implement a time-programmed control program. In this case, the signals are recorded using some kind of reproducing device (for example, a tape recorder), which at the right time gives the appropriate command [100].
2.312.3. Parallel transmission of several commands. So far, it has been a matter of transferring only the
telecontrol technique
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one continuous control command. If it is necessary to transmit several (n) commands simultaneously, then the control systems discussed in the previous sections should be repeated in the general case n times. This, in particular, means that the systems shown in Fig. 18, 19 and 20, corresponds to the following number of required command frequencies:

The number of required command frequencies is
18, and n
18.6 n or n + 1
18, in -b 2
19, a / 20, and n
19.6 / 20.6 2n
In the case of pulsed phase modulation (Fig. 20, c), it is exact in the same way as in the case of modulation of the pulse duration at one carrier frequency, the entire period of the main pulses (T) must be dissected to transmit individual commands. In fig. 25 is a timing diagram for transmitting six independent commands from each other. The first (ninth) partial period is necessary for the synchronizing pulse, while the eighth (n + 2) partial period serves to maintain the gap between the command and synchronizing pulses. The equipment that works in this way is described in [110] as applied to telemetry targets. For equipment with pulse amplitude modulation see [77, 90]. Otherwise, regarding the new possibilities of pulse modulation, one can refer to special literature, for example [18–22, 102].
Values
coma tda II 0 m 1 I KS. I w I! I I «= x = ~ l + 2 | II
Partial periods Purpose 1 Sync. 2 K ', 3 "2 k * 3 -' 5 G-6 K5 7 * 6 8 1 Sync.
Fig. 25. Pulse phase modulation for transmitting n e »6
commands.
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In order to prevent confusion of concepts, it is necessary to emphasize once again that two categories of “modulation” should be distinguished: on the one hand1, is the change in some quantity (amplitude, phase, etc.) considered in Section 2.312.2 that contains the command value, and on the other hand, a method of modulating the carrier frequency with an intermediate signal (for example, a low frequency) containing the command value. For this last category, in principle, all known types of modulation are applicable, which can only be listed here:
The type of modulation used in each individual case depends on many factors, some of which are mentioned in Section 2.7. Improvements are likely to go in the direction of pulse modulation, especially pulse phase modulation.
The question of direct current signal transmission via wires (2.332.21) is exceptionally simple if only 1 or 2 continuous commands are to be transmitted. In this way, for example, telecontrol of an X-4 shell was carried out (see 3.524.1, Fig. 92, and also Fig. 54).
If, according to the method of commands, certain, so to speak, ready-made commands are sent to the remote-controlled object, then during radio-beam control, the formation of commands takes place on the remote-controlled object itself. At the control point, he is given only a certain line in space along which he must move. This guide line is, in general, straight,
1 See notes on page 48.
Pulse Amplitude Modulation (IAM) Pulse Frequency Modulation (HMI) Pulse Phase Modulation (IFM) Time-Pulse Modulation (VIM)
Pulse Code Modulation (I ' KM)
amplitude modulation frequency modulation phase modulation
(AM)
(FM)
(FM)
2.32. Equal Signal Method Telecontrol
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designating an equal-signal zone. If we are talking only about one degree of freedom,

then instead of the beam there is a guide plane (often also called a guide beam). In principle, however, the guiding ray or plane can be curved, as, for example, with the hyperbole control method [63].
Fig. 26. Schematic diagram of radio remote control.
In fig. 26 is a diagram of a radio beam control system [56]. The transmitter P is connected through a switching device KU to a directional antenna HA, the radiation pattern of which periodically changes so that a directing beam (or, accordingly, a plane) arises. A signal appears at the output of the directional radio receiver Pr, which allows you to find out in which direction the telecontrolled object deviates from the directing beam. This signal is then converted into an SD control device of the on-board control system, and the op-amp control body moves so that the telecontrolled object receives corrections for returning to the guiding beam.
2.321. Creating a guide beam. The guiding beam, in principle, arises due to the fact that due to the radiation field in space, a line is created along which the field is very different from the field adjacent to this line. Signs of this difference may be as follows.
2.321.1. The greatest field strength. A prerequisite for creating the greatest field strength is a very sharp radiation pattern of the source.
2.321.2. The smallest field strength is created due to the radiation pattern with a sharp depression in the direction of the beam axis.
Point P ^ andoluch
Telecontrolled control
object 62 Chapter 2

2.321.3. Constant field strength. Technically, it is very difficult to implement for guiding beams of interest to practice (for example, early attempts to fly in the vertical plane - the “glide path beacon” - in a blind landing system).
2.321.4. A certain phase ratio. It exists between the fields of two or more frequencies that are emitted with an unchanged phase: for example, “Dessa” - the method used in aircraft navigation along a hyperbole [1, 17, 63], gives a directing plane only for horizontal navigation.

2.321.5. The same field strength. It is created when there are two different sources of radiation. The latter method is widespread, and the high-frequency transmitter in any way (for one plane) periodically switches to two antenna systems in such a way that there are two identical, but shifted by a certain angle radiation patterns (elliptical or lobe-shaped), the intersection points of which form the direction of the control plane as shown in fig. 26. Instead of switching to two antennas, mechanical or electrical rotation of the radiation pattern with one antenna can also be used.
2.322. Determination of deviation from the guide beam. To create the possibility of using a guide beam on the receiver side, it must be formed in such a way that it is possible to determine the direction of the deviation of the object from the guide plane. Common methods for this are:
2.322.1. Time-asymmetrical switching, for example, in the rhythm of a dot - dash.
2.322.2. Time-symmetrical switching with simultaneous switching of modulation; for example, different sound frequencies are given to both emission petals.
The most famous application of the first method is aircraft landing on instruments: in this case, the vertical directing plane is set by the directional landing beacon, the second directing plane is

the speed (theoretically a plane inclined at a "planning angle" to the horizon) is defined by a glide path beacon. For the rest, we refer to special literature [1, 17] (see also section 3.6).
Guidance in the guide plane of the V-2 shell is carried out according to the second method. See sections 3.511.16, 3.522 and fig. 19 [26.6, 71-73]. In the same way, distant drive beacons (in principle, even light and infrared) can work. In all these cases, we are talking about a permanently installed, that is, motionless directing beam in space. However, if the directional antenna is designed to be rotatable (mechanically or electrically) and monitors a moving target, then the actual "control point" arises. According to this method, for example, projectiles ("electric artillery barrels") can be aimed at a moving target, and for the second plane, the system can be repeated, and the radiation diagram can rotate around the direction of the control beam.
2.323. Regulation on board the facility with radio beam control. The previous sections often said
about "regulation". This function, that is, the transmission to the control body of a control signal that is correct in sign and magnitude, resulting from the deviation of the object from the guiding beam, falls on the "control device" of the onboard control system of the SD, shown in Fig. 26. The deviation of the telecontrolled object from the axis of the radio beam is set by a directional radio receiver. If we proceed from the usual indicators of receivers intended for driving along a radio beam - for example, for blind landing - that is, devices whose arrow deviation is a measure of deviation from the axis of the equal-signal zone, then it is enough to use servomotor control devices instead of pointers to obtain a control circuit. A complete circuit can be obtained, for example, as a result of a replacement in the circuit (Fig. 6) heading gyroscope indicator directional radio, the pointer of which is equipped with a potentiometric sensor. In this case, damping elements also play a large role [26.6, 64]. Regulation scheme

V-2 for radio beam control is described in detail in section 3.522 (see Fig. 76, 77).
2.33. Methods of transmitting telecontrol signals
Transmission of a command from a command post to a telecontrolled object can occur either by radiation or by wire. For completeness, we also mention the purely mechanical cable transmission used for toys and moving models (for example, flight

on a cord).
The choice of a particular type of transmission to solve a specific problem is determined primarily by the state of the art in the relevant field, as well as the required radius of action. Here you can only list the main methods used.
2.331. Radiation. It can be used for transmission under control both by the method of commands and by the method of an equal-signal zone.
2.331.1. Electromagnetic vibrations.
2.331.11. Radio waves (the entire spectrum of high frequencies from long to centimeter waves).
2.331.12. Thermal (infrared) radiation.
2.331.13. Light emission.
2.331.2. Elastic vibrations (in water or in air).
2.331.21. Sound waves.
2.331.22. Ultrasound waves.
2.332. Conductive transmission. Applicable only to the command method.
2.332.1. The difference in the number of wires.
2.332.11. Single-wire transmission (return wire. - earth, water or - at high frequency - atmosphere).
2.332.12. Two wire transmission. When transmitting several commands in parallel (2.312.3), several carrier frequencies or the use of selection is necessary.
2.332.13. Multi-wire (cable) transmission. With n command channels, n + 1 cores are necessary, in the case of selection, less.

2.332.2. The difference in the type of current.
2.332.21. DC transmission.

2.332.22. Low frequency transmission.
2.332.23. High frequency transmission (by wire).
The various transmission possibilities [52] are summarized again in Table. 6. Tab. 7 contains a spectrum of known frequencies. It can be seen from the tables that in telecontrol only a small part of the theoretical possibilities are used in practice: ultra-short waves in the decimeter and centimeter ranges are mainly used for telecontrol of radiation, direct-current and low-frequency transmission for wire telecontrol (for application examples, see 3.511 )
2.333. Combinations of transmission methods. Various combinations of transmission methods are also possible. An example is the Italian Grotstsi project. The torpedo is dropped from the plane along with the buoy. On the water, the torpedo is separated from the buoy and receives control commands from it that are sent by the radio transmitter and received by the receiver on the buoy from it. The creation of this system, which seems somewhat cumbersome, was due to the strong absorption of ordinary radio waves in water. The only project known to the author for wireless control of an underwater torpedo aircraft, control, NY (3.511.15) with a carrier frequency of 100 kHz, was unsatisfactory.
2.4. COORDINATE DETERMINATION METHODS
The best methods of telecontrol will be useless if methods are not applied that allow you to set the initial data for setting the “correct” telecontrol commands. This is, generally speaking, about problems of determining coordinates. In each case, these tasks may look different and, accordingly, be solved differently. This section provides an overview of the most important possibilities for solving coordinate control problems. As for the details of installations for determining coordinates, and especially radar devices, you should refer to the special literature [1, 2, 17, 26.3, 26.4].
First of all, it is possible to distinguish whether a telecontrolled object is aimed at a specific target or whether it is necessary.

Tables 6, 7,
Methods of transmitting telecontrol signals
Radiation Wires
electromagnetic electromagnetic Number of wires Current type
Radio (HF) Thermal (IR) Sound Sound Ultrasound Single-wire Two-wire Multi-wire DC-Low frequency High frequency
[It is applied
I It is applied I $ special cases
P-passive A-active
Application is possible or of interest

wives move along a certain trajectory. Further, you can set the condition that the object takes a certain position, speed, etc.
Let us first consider the most common case when a telecontrolled object is aimed at a specific target.
2.41. Methods of targeting
It should be distinguished [92]:
2.411. Aiming — determination of the coordinates of the target, selection of the direction and moment of launch, pre-installation of control sensors (programs) for autonomously controlling objects.
2.412. Actually guidance — determination of the initial data for issuing the “correct”

telecontrol commands in order to correct the trajectory of controlled objects.
2.411. Aiming.
2.411.1. The starting place and the target are fixed. In this case, the aiming takes place on a visible target or on an invisible one (a map is used) taking into account external influences (for example, wind) similar to normal aiming during artillery fire. If the exact position of the target is unknown and cannot be determined before the start of the telecontrolled object, then the approximate direction to the target is the basis for aiming, and subsequently, as soon as the object itself has "caught" the target, its trajectory is corrected by the method of target designation or homing.
2.411.2. The place of start or observation and the target move relative to each other. Moreover, generally speaking, before the start there should be a connection between the observation point1
1 "Observation point" - the location of the "observer", that is, the person who is engaged in determining the coordinates. "Control point" is the location of the "operator" (for tele-controlled weapons - the "arrow-operator"), that is, the person who issues telecontrol commands using command sensors or a device defining a directing radio beam. Observer and Opera -
5 *
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and purpose. In this case, the same method of determining the coordinates is used as possible as when correcting the trajectory during the guidance process. The simplest solution is when the start location of the telecontrolled object can be considered as the point of its trajectory, to which the same basic conditions apply as to all other points (see Fig. 34). If this is not (for example, with the vertical take-off of missiles), then the intermediate inclusion of special computing devices or software control is necessary. In general, methods that are usual for a "shot" of uncontrolled bodies are also applicable, using calculating devices, generating lead angles, parallax devices, etc. This generally also includes determining the distance to the target, but this can for the most part be discarded during the subsequent correction of the trajectory during the guidance process. If the exact position of the target before the start is unknown, then what is said on this subject in 2.211.1 is valid.

A special case is a natural relative movement of the launch site and the target, as it can be when pointing from celestial bodies (natural or artificial). In this case, the exact start time, which is established by calculation [8], is very important.
2.412. Actually guidance. The most common case occurs when the control or observation point and the target move in space. The task then is to determine the relative position of the telecontrolled object and the target, and in general it is enough to establish the relative position along two coordinate axes, while the distance to the target is only of secondary importance (for example, when attacking ships or planes from an aircraft, see Fig.
1 and 2). Possible methods are presented schematically.
The torus may be the same person or different persons. In the latter case, the observation point and the control point may be in space at various points. In each case, the coordinate determination equipment and the control equipment belonging to the corresponding points can be distributed in space as desired.
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in Fig. 27, and the notation corresponds to the notation in Fig. 3 [52].
Point of occupation and control of
the property
q) The method of co-operation v (and panoramic method)
6) The target designation method
c) The homing method:
passive
active
| ~~ \ * and -_____ semi-active
y ////. Issuing commands Исполн Executing commands Линия Telecontrol signal transmission line
--- ^ Target communication line
---- *> Information transmission line
Fig. 27. Scheme of methods for determining coordinates.
2.412.1. Matching Method 1. The object is controlled in such a way that at each moment of time it is on a straight line (or as close as possible to it) connecting the observer and the target, and its trajectory
1 It is also called the three-point method. - Note
ed.
Chapter 2 is
defined by two given trajectories and three speeds. Fig. 28 gives a basic idea of the matching method for one plane [56]. The position of the observation point, remote control object
and goals for identical times 1 and 2 are denoted by the same numbers. The curvature of the trajectory in this case is insignificant (see also Fig. 34, curve 1). Coordinates can be
determined using the registration method: 2.412.11. Optically. If the target and the remote-controlled object are visible from the observation point using illuminating means and optical devices, then the observer-target and observer-object lines overlap each other, hence the not-so-correct name for this method is “double overlap”.
2.412.12. By radio, infrared and other means. In the absence or unreliable visibility, a direction-finding beam acts instead of the visual beam. This direction finding can be carried out1 using radio engineering as well as thermal (infrared) or acoustic means (sound, ultrasound, especially underwater). Since the coordinates of two objects must be determined at the same time, namely:
a) the coordinates of the target,
b) the coordinates of the object,
1 See table. 7, columns 10 and 11.

i
The trajectory? "Of the target
\ z
Fig. 28. Combination method.

then the system should be designed so that it is possible to observe the bearings separately or the bearing of the object relative to the direction to the target. In this case, the remote-controlled object is equipped with a transmitter1, and a receiving direction finder is installed at the observation point. Two cases should be distinguished in determining the coordinates of a target: a) the target itself radiates, so that its coordinates can also be determined using a receiving direction finder (for example, at a different frequency); b) the target does not give radiation, its coordinates can be determined using direction finding of the rays reflected from the target, that is, using radar [92]. In fig. 29 schematically shows the necessary system for this; equipment costs are already significant [52, 56]. An example is the Rhineland anti-aircraft missile system (see section 3.525.2).
No.
UE
(T0) 1
/1
%} UL
Control point
PRP -f (
Lmjr "w
! NII - | L *
—N pl ' Direction finding
point Target (C) * o Fig. 29. Coordinates determination and control by the method of combining with the inverse target bearing and receiving bearing of a telecontrolled object. DK - command sensor; PC - command transmitter; PrK - • command receiver: UR - control device; OU - control body; PP - direction-finding transmitter; PrP - direction-finding receiver; UP (TO) - pointer bearing (telecontrolled object); PrL - locator receiver; PL - transmitter locator; UP (C) - pointer bearing (target).

2.412.13. In conjunction with radio beam control. The need for a special determination of the coordinates of a telecontrolled object disappears if for control
1 or the defendant. - Note ed.

applies the radio beam guidance method [2.32]. In this case, the device for determining the coordinates of the target — both with optical and other methods — is directly connected (or, if necessary, through a parallax calculating and resolving device) to the radio beam guiding system. In fig. 30 is a schematic representation of such a system. A method for determining coordinates, which, although it does not come from combining bearings, but also works according to the scheme (Fig. 27, a), is the stereoscopic method.

Click Control
RP
KU
>
item
direction-finding
tion
KC
1LR | ---
the X
5 = 0
The purpose of
Fig. 30. Determination of target coordinates by the radio beam control method.
RP - equal signal transmitter; KU - switching device; KC - goal coordinator; PR - parallax calculating device; RPr - equi-receiver; UR - • regulation device; Shelter - the governing body.

2.412.2. Stereoscopic (panoramic) method. With this method, due to the electromagnetic (radar) survey of the space sector of interest, an electronic image is obtained, on which the corresponding positions of the target and the telecontrolled object are visible, and the mark corresponding to the telecontrolled object should have an identification sign by which it could be distinguished from the target mark. The control takes place in such a way that the trajectory of the telecontrolled object is directed to the selected target. To determine three coordinates (spatial motion), it is necessary to have two separate devices, since the possibility of distributing coordinates in one image is always limited to only one plane. Various telecontrol techniques can be applied to determine different coordinates.
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methods, for example, for determining the coordinates of a body in the air from the ground: azimuth - according to the panorama (or rather "according to a flat image" in the horizontal plane), elevation angle - from the radar bearing.

The stereoscopic method has been used for several years to regulate air traffic and to guide fighters [1.15], however, in the form of piloting by telecommands [54], that is, by issuing commands to the pilot with voice over a radio link. Replacing it with a command line (Fig. 9) does not mean any difference with respect to the coordinate determination process.

2.412.3. Target designation method. With this method, the coordinates of the target are determined on the remote-controlled object, and the result of this determination is transmitted to the control point, commands are sent from the control point to the object in order to direct its movement to the target. Fig. Fig. 31 demonstrates the essence of this method (in this case, it does not matter where the control point is), and Fig. 32 is a diagram of systems implementing this method [52, 56]. The last figure allows you to see that the costs on board the remote-controlled object when controlled by this method increase in comparison with the costs of the combination method. The method for determining the coordinates, determining the design of the coordinator of the target, can be built using television and direction finding.
f
/
Fig. 31. Target designation method.
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Control point Remote-controlled object
Fig. 32. Coordinate determination and target design.
DK - command sensor: PC - command transmitter; UK - coordinate pointer; PrKt - coordinate receiver; PrK - receiver commands; KC - target coordinator (target

designation device); PCT - coordinate transmitter; ОУ - governing body; UR - regulation device.
2.412.31. TV. In this case, the target coordinator of the CC is a television camera; the image received in it is sent using the PC transmitter to the control point; Images can be optical, infrared, or electron-optical, see 3.512.
2.412.32. Direction finding Depending on whether the target itself emits or not, the coordinator has a receiver of direct radiation or reflected radiation from a transmitter (for example, a radar). The latter has the advantage that it is easy to simultaneously determine data on the distance to the target. But in this case, the choice between many goals is very difficult. These difficulties can be best overcome both with the television method and under certain conditions with the panoramic method (see 2.412.2, as well as 2.76).
2.412.4. Automatic control and determination of coordinates. Both with the combination method and the target designation method, it is possible to automate the issuance of commands by linking, using special equipment, electrically or electromechanically, the target coordinator with the command sensor. The coordinate determination process itself can also be automated by generating a control signal in the coordinate indicator, with the help of which the device for determining coordinates (for example, the direction finder antenna) is automatically sent to the target.
DK - A PC ->
UK - npHi h
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With the target designation method, television or direction finding, this can be done bypassing the control point located outside the telecontrolled object and “short-circuiting” the coordinate indicator with the object control device. The circuit in fig. 32 then turns into the one shown in fig. 33 is a schematic diagram of the homing method, the principle of which has already been described in
2.13.
-O Purpose
Managed object
Fig. 33. Schematic diagram of a homing system.
KC - goal coordinator (homing); UR - regulation device; ОУ - an object management body.
Depending on whether the target in space creates fields that can be used for homing purposes or does not create, three methods can be distinguished:
2.412.41. Passive method. The energy used to determine the coordinates is radiated by target1 (direct bearing);

2.412.42. The active method. The target is irradiated from a telecontrolled object at the carrier frequency of the coordinate determination device (inverse bearing);
2.412.43. Semi-active method. Irradiation of the target required for direction finding of reflected radiation is performed from a point located outside the telecontrolled object (for example, from the launch site). Homing method
1 If the target does not radiate, then in some cases a radiation source (transmitter) can be placed on it, which the object is aimed at using the homing device.

discussed in detail in section 2.5, various forms of energy are highlighted in detail (for application examples, see 3.513).
2.413. Trajectory. The trajectory of a telecontrolled object along which it moves toward a target depends on the following factors:
1. start location, start direction, start time;
2. the movement of the observer j during the refinement of the trajectory
3. the movement of the target [the projection in the process of guiding
j
4. the speed of the tele-controlled object;
5. method for determining coordinates.
From fig. 28 and 31 that the trajectories with the combination method and the target designation method (and homing1) will look completely different, since in the first case only the location of the object at a given moment is decisive, and in the second - the instantaneous position of the longitudinal axis (in the simplest case coinciding with the tangent to the trajectory, i.e. with the direction of movement). In fig. 34 shows the trajectory curves of a telecontrolled object (for example, an anti-aircraft missile [52, 56, 93]). When constructing the curves, it was assumed that the observation point and the control point are motionless, and the speeds of the target and the remote-controlled object are constant and relate as 2: 3.
Trajectory 2 is calculated under the assumption that the axis of the coordinator (for example, a television camera) coincides with the axis of the telecontrolled object. In this case, the so-called “pursuit curve” is obtained [111, 112]. It is easy to see the following fundamental differences between the two trajectories in Fig. 34:
a) the length of the path 2 is greater than the path 1;
b) the radius of curvature of trajectory 2 is less than that of trajectory * 1;
c) the intersection of trajectory 1 with the trajectory of the target occurs at a large angle, and trajectory 2 at a zero angle.
1 Here we are talking about only one version of the homing method, the least perfect in a large group of modern homing methods. - Note ed.

Fig. 34. Trajectories of telecontrolled objects.
Point “b” is important for practice, since telecontrolled objects are able to follow trajectories with a limited radius of curvature. In order to straighten the “pursuit curve”, the coordinator can be set so that its axis forms a certain angle with the longitudinal axis of the telecontrolled object. In this case, they speak of a “mowing” installation of the coordinator (for example, a homing device) and a “distorted pursuit curve”. The installation angle can be constant -

new or variable. Changing the installation angle can be done using program regulation, telecontrol commands or automatically (see section 2.25). The latter is applied primarily in homing systems and in some cases represents the only way to solve some problems, all the more so as a reduction in the total path length to the target can be achieved (for more details, see 2.53, 2.54 and 2.75).

## 2.42. TRAJECTORY TASK

2.421. A predefined path. In the previous sections, the trajectories resulting from aiming at the target by various methods were considered. The task, however, can sometimes be such that a telecontrolled object is predefined a certain trajectory in space. In this case, in principle, the methods for determining coordinates discussed earlier are applicable. The difference is that now it is not a question of determining the relative position of the target and the telecontrolled object, but of setting the program. The possibility of application consists, for example, in conducting test flights without a crew, and the telecontrolled object must follow a predetermined path. Suitable for these purposes is the equal-signal area method (2.32). Using it, it is possible, for example, to make a telecontrolled object start on a radio beam; along it the object moves to the intersection with another radio beam, to which it then "turns". This occurs, for example, when navigating a hyperbole [1, 15, 17].
The panoramic method
(2.412.2) can also be easily applied , whereby the prescribed trajectory is applied on the screen in advance and the luminous marks corresponding to the position of the telecontrolled object are combined with it. An example of maintaining a predetermined trajectory with a length of more than 1000 km is a transatlantic flight made by an American aircraft in 1947 [65, 66]. This flight is discussed in section 3.6. In this case, we are talking about the alternate application of the

the autonomous control method and the target flight method.

2.422. Measurement of a trajectory. In addition to controlling along a specific path, it is often of interest to measure the actual path, which will not be considered in detail here. Specific cases of this method are described in the literature [26.8, 71, 108].

2.43. Monitoring the flight mode and operation of the units
In addition to obtaining the initial data for remote control, it may be required that data on the flight mode and operation of the units on board the remote-controlled object be transmitted to the control center. Here we are talking not so much about problems of determining coordinates, but about special problems of telemetry.
2.431. Measurement on board. If the value that needs to be measured is determined directly on board the telecontrolled object, then it is necessary to install an additional sensor of the measured value and transmitter on board the object, and in the control point or some third place - the corresponding receiver with indicator or recording devices. A method that allows the simultaneous transmission of many data is, for example, to transmit to the control point a television image of the corresponding on-board devices, where it can be recorded on film. There are other methods [109, 110]. If the readings of the on-board instruments are used in order to cause changes in the flight mode and operation of the units by the reverse transmission (according to the telecommands method, see 2.31 and 2.62), then we are again dealing with the task of telecontrol, called "TV driving" [54]. At the same time, it is also possible to automate processes by connecting indicator equipment with telecontrol equipment. In this case, it is possible to work with a "short circuit" (2.412.4), that is, bypassing the control point. The reading is converted into a control signal in an open or closed control system of one or another value on board the object. As
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As an example, you can point out the regulation of engine thrust from the pressure sensor during automatic landing of aircraft (see 3.6) and the command to stop the engine at the V-2 from the speed sensor (accelerator integrator, see 3.522).
2.432. Measurement from other points. Another possibility is to measure the value directly at the control point or in some other place. As an example, one can point to the measurement of the speed of a flying object, carried out using the Doppler effect in long-range and high-altitude missiles. This is briefly reported in section 3.522 (Fig. 78) and in other literature [11, 26.3, 71, 72, 73, 108].
2.5. SELF-
GUIDANCE METHOD 2.51. Key Points
The principle of automatic homing was defined in section 2.13 as follows: the controlled object has a special device (homing head) 1 that allows it to determine its own position relative to the target or relative to other points that should determine the trajectory of the object. Control signals arise due to the deviation of the direction of movement of the object (or its axis in space) from the direction specified by the coordinator of the target.
Since this method is a combination of control and coordinate determination tasks, homing was also mentioned as a means of determining coordinates (see 2.412.4 and 2.254).
2.511. Circuit diagram. From the above considerations, the circuit diagram shown in Fig. 33. The coordinator contained in it - the "homing device" - must determine the position of the controlled object (or only the direction of its longitudinal axis or tangent to the trajectory) relative to the direction of the object — target and convert the deviation into a control signal so that the
x homing head includes target coordinator and a number of additional devices. - Note ed.
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using the actuator to act on the control.
The determination of the relative coordinates at the object can be carried out using automatic direction finding, for the implementation of which there are devices of various types [1, 15, 17]. The most common method is the differential direction

finding method, the circuit diagram of which is shown in Fig. 35.
reference (receiver) "—x v
Fig. 35. Homing system with a differential method of direction finding of the target. The
petal pattern of the receiving antenna I periodically rotates (switches) by an angle of + ultrasound. For the position of the target (transmitter) Tsg at the output of the homing receiver I a voltage appears, the magnitude of which depends on the difference in the angles of B. This difference voltage becomes equal to zero at e, that is, when the target is in the point Tsg or in the plane of symmetry of the oscillations of diagram 1.
The most famous application of such a device is the orientation of the aircraft in flight at any known radio station. At the output of the directional receiver, there is a device whose readings are a measure of the deviation of the aircraft course (or lead line) from the direction to the target (transmitter).
1 It should be noted the difference between this targeting method and the equal-signal zone method (2.31, Fig. 26). In the latter case, the direction in space is set at the control point (directional radiation transmitter, circular reception); with automatic homing, on the contrary, this direction is set in the telecontrolled object (circular or directional transmission, directional reception).

6 Telecontrol
\
-d Purpose / (transmitter)
Self-apparatus- \

2.512. Regulation. There are two ways of regulation:
2.512.1. For one plane. Mentioned pointer device on a ship or aircraft is installed in the field of view of the navigator or pilot, which will transform the deviation into a command command. To automatically aim at the target in one plane, the control signal removed from the output of the receiver must be converted to moving the control. The control device (UR) necessary for this (Figs. 33 and 35) can be performed in exactly the same way as with radio beam control (2.323).
2.512.2. For two planes. When a controlled object moves towards an airborne or ground-based point target, it is required to provide coordinate determination and control in two planes (1.412). To do this, there are the following options:
2.512.21. Repetition of the system with a shift of the plane of the diagram by 90 °.
2.512.22. Application of a rotating receiver radiation pattern. The following can be used
as indicator devices for non-automatic flight control: a) two indicator devices, one on each plane;
b) a cathode ray tube with a screen as a pointer 1. For an automatically controlled flight to a target — actually homing — it is necessary to create two control devices, respectively. When direction finding is separate for both planes (2.512.21), the control device is repeated for the other plane, according to 2.512.4. With a rotating direction finding system (2.512.22), the control voltage from the receiver is removed, for example, by a switch rotating synchronously with the diagram, and introduced with the corresponding phase (0/180 °, 90/270 °) into the control device of the onboard control system (see, for example, Fig. 63).
1 Some passive installations of this type are given in table. 9 and 12. The German active target-flight installations were primarily systems with modulating devices.

Completed or planned homing installations are summarized in table. 12 (3.34) and described in 3.513. Now we should briefly consider the general provisions that are relevant to the design and installation of homing devices. First, you need to find out some concepts related to the operation of homing settings.
2.52. Basic concepts
The line of sight is the direction of the neutral axis of the homing system.
Capture range (range) - the distance between the homing installation and the target at which the homing installation works reliably, that is, it gives out sufficient control signals.
Coverage angle1 is the angle relative to the axis of the homing installation (line of sight), in which the target must be located so that the operation of the homing installation is ensured (e <a, Fig. 35; it is better to give + a / 2).
Installation angle - the angle between the axis of the homing installation (line of sight) and the axis of the homing object (o-, Fig. 36).
Search angle - the angle within which the space is “viewed” by the homing installation.
The angle of the target (the angle of deviation from the target) is the angle between the line of sight and the direction to the target (<e, Fig. 35).
The angle of inclination of the trajectory is the angle between the tangents to the trajectories of the telecontrolled object
and. moving target (y, Fig. 36).

The output quantity is the electrical or mechanical quantity that appears at the output of the homing installation as a measure of deviation from the target. It is used in the onboard control system for aiming at a target.
1 This value is also called the angle of view. - Note
ed.
6 *
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Establishment accuracy - the accuracy (angular deviation) with which the axis of the tracking homing system focuses on the target.
36.1 Alignment curve, pursuit curve, distorted pursuit curves.
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Sensitivity is the smallest angle at which the output value is still sufficient for the homing system to monitor the target.
Tracking speed - angular velocity rad / sec with which the homing system accompanies the target.
_) The
accuracy of control of the INNIGHT of the body is indicated by the guidance
speed of the control (controlled by the entire object.
The switching frequency is the reciprocal of the period of the radiation pattern (2.511).
2.53. Trajectories
Some basic considerations on this issue have already been outlined in 2.413. clarification of the provisions indicated there in relation to the installation of homing devices (or target designation) on board the object should be considered in Fig. 36.
The graph shows a special case of movement shown in Fig. 34, with the
following omissions1: the
target moves rectilinearly at a constant speed
C;
the start place coincides with the observation point (point O);
the start occurs at that moment in time when the target passes at the smallest distance from the start location (time O);
the controlled object moves from the start with a constant speed V = 3 / 2C (as in Fig. 34).
Both vehicle curves (alignment path) and 777 (pursuit path) correspond to those shown in Fig. 34 trajectories 1 for the combination method and trajectories

2 for the target designation or homing method with the installation angle o- = 0.
Here, the differences between them indicated in 2.413 are also well expressed.
If we now position the homing system so that its line of sight does not coincide with the pro

1 It should be emphasized that the curves presented are the so-called kinematic trajectories corresponding to the perfectly accurate execution of the links superimposed on the object’s velocity vector. - Note ed.

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longitudinal axis of the controlled object, and formed with it a constant "installation angle", for example cg = 30 °, you will get a "distorted pursuit curve" of the SEC. Moreover, it turns out that it has not only shorter length and less curvature of the trajectory than the pursuit curve 777 with cr = 0, but it proceeds even more favorably than the curve
Q
vehicle combination. In the boundary case cr = o-0 = arc sin -, the
distorted chase curve turns into a direct TP0, which under the accepted conditions of launch and flight speeds gives the shortest travel time or, in other words, the longest range. The angle c0 corresponds in this case to the “lead angle” when firing unguided projectiles at a constant speed.
The travel time along the TP0 trajectory (Fig. 36), equal to 13.4 units of time, can be reduced even more if you do not wait with a start until the target reaches point O, but to make it earlier. In fig. Fig. 37 shows the corresponding curves for the “-10” start moment when guided by the combination method and homing method.
When considering Fig. 37, it becomes clear that both curves, TS and TP (for σ = 0), although they show a shorter approach time than in Fig. 36, but have greater curvature. Here it is also possible to achieve straightening of the trajectory by choosing the installation angle accordingly. In the boundary case, we also obtain the direct TP0. If the start time, as shown in Fig. 37, is selected so that the contact point for the case of rectilinear motion of an object lies at the point of the trajectory
TP
target (the movement in units equal to 10, y = 90 °),
Y
Q
then there is a ratio m0: o 0 = arc tg-.
2.54. Guidance The
transition from these considerations to the practical guidance of homing objects is relatively simple if you accept that:
1) the capture range of the homing installation is so large that the goal is already from the moment of starting the “capture-
alignment
Transition —TS eTP,
I * 9cGo = Ж = T
TC 04
Trajectory Method a
TГ alignment time 0-45 ° 11.1

homing 0 14 , 0

tp „----- and 33.7 ° 10.0
- / 0 -2 combined. OT-2: SSSHYUNAVD. 0-30s tff = 30 ° 10.9
1 and, ---------
-10 And Start the
pursuit curve with the forward moment of the start.

chena ″by the installation of homing and subsequently all the time is kept in its‟ field of vision ″;
2) the direction and speed of the target does not deviate significantly from the values recorded at the start of the controlled object.
In this case, it is possible to dispense with a system in which the angle c is set in advance in accordance with the admissible curvature of the trajectory of the induced object. The start takes place at the moment the target crosses the line of sight of the homing installation, which in turn, through the regulatory system, affects the controls. If this happens in the case c = 0, that is, in the case of a rectilinear trajectory of the object, then this process corresponds to the normal aiming process with anticipation, and the homing system should make only minor adjustments to the trajectory of the object. The fulfillment of these conditions depends on the corresponding statement of the problem. So, for example, the second condition is fulfilled when it comes to aiming at a fixed target (for example, a fixed radio transmitter, a light beacon, a fixed ground target).
If in these cases the first condition is not fulfilled, then the controlled object must first of all come so close to the target, controlled autonomously (or not controlled) so that the target is in the range of the homing system. However, before the homing system can take over the automatic control of the object, it is necessary to ensure the "capture" of the target. The connection between the output of the homing installation and the controls (regulation) can only be carried out when the output values issued by the homing installation are quite certain1. To guarantee this, the following methods are used. After the first capture of the target, the homing system itself is controlled at first

1 More precisely, the transfer of control to the homing head should be carried out when the ratio of the useful signal at the head output to the interference level exceeds a certain value. - Note ed.


so that her line of sight accompanies the target. When the predetermined installation angle is then passed, the relay switches from tracking the target with the homing head and tracking it with the entire telecontrolled object. This is advantageous in that the automatic transition from the initial trajectory to the distorted chase curve occurs when the longitudinal axis of the controlled object has the “right” direction and the transition itself is not accompanied by large angular accelerations. The application of this method is also possible in the case when both of the above conditions are not satisfied. You only need to make sure that:

a) the controlled object already at the time of approaching with a target lying outside the range of the homing head reacted to the deviation of the target from a predetermined and extrapolated trajectory;
b) the capture angle of the homing installation was so large that upon reaching the range of the homing installation the target would be immediately captured. ”
The solution for "a" is that the object from the moment of start to the moment of approach for the purpose of telecontrol, which can be carried out, for example, by the combination method (2.412). In fig. 37 shows such a transition from the vehicle alignment trajectory to the TPH homing path when reaching an angle equal to the installation angle (about -30 °). The graph shows that the deviations of the trajectory TIJi from the last section of the trajectory of the vehicle are very small, that is, with such a transition, only small additional accelerations appear.
A prerequisite for the implementation of this method is the capture of the target by the homing device already before passing the point corresponding to the value a-d (see "b"). For all practically implemented homing systems (3.513), the capture angle a is so small that condition “b” simply cannot be fulfilled. To increase the effective angle of capture, you can periodically change the installation angle o- so that the homing installation “looked through” more than
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space in the direction of the target (“search angle”, see 2.52; in one plane, oscillations; in space, rotation of the homing head). After capturing the target, a special relay is triggered, and the line of sight of the homing installation follows the target, that is, as mentioned earlier, the homing head monitors the target until a predetermined angle is reached. But, instead of stopping the homing head in this position and creating a “rigid” homing head in this way, it is often advisable also to leave the head movable during the automatic aiming of the target. At the same time, it can track the target with high speed, while the axis of a controlled object with great inertia has the ability, for its part, to follow the line of sight. This ensures that
The main thing has already been said about the technical implementation of control devices (2.512). If a scheme is adopted according to which target tracking is carried out initially by the tracking homing head, then instead of the controls for the object, the head turning engines act. Design features primarily depend on the type of output value of the homing installation. Here, as with autonomous control or telecontrol, it is also possible to apply control on the principle of “yes-no” or continuous control. The best effect is achieved in systems where the output value is proportional to the deviation from the target2. Reg-
1 There are also forms of application in which only the homing head is automatically induced, and the moving object on which it is mounted is not controlled from it. As an example, we can mention an optical measuring device aimed at the sun (for example, a spectrograph) mounted on a high-altitude rocket used for research purposes.
2 Contrary to the author's assertion, nonlinear, and in particular relay, systems in some cases provide better control quality than proportional action systems. - Note, ed.
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ligation can then be performed in a closed (tracking system) or open circuit (2.312.1). To guide the controlled object itself, signals can be generated, for example, by potentiometers. A voltage proportional to the current value of angle c is removed from one potentiometer, and a set value c1 is set on the other potentiometer. When controlling around two axes, there are two such systems, they are offset 90 ° from each other.
If instead of a control system between the determination of coordinates and the issuance of control commands a person acts as a target designation method

(2.412.3), then there are various options for setting target coordinators. At the same time, the following types of installations on flying objects are distinguished mainly:
a) motionless on board;
b) constant on the oncoming flow;
c) constant in direction;
g) turning (tracking).
Types “c” and “g” give generally the smallest hit errors. They arise, apart from the inaccuracy of the control, due to the fact that upon reaching the known curvature of the trajectory of the pursuit, the telecontrolled object seems to be turned off from the control; then it flies in a circle corresponding to the smallest permissible radius of curvature rmin (the latter is, for example, 750 m at a flight speed of v = 200 m / s and centripetal acceleration bT ~ 5 Ad). The magnitude of the hit error also depends on the angle of the trajectory / relation
„v, the
velocities -, as well as on the maneuver of the target1.
FROM
German aviation research institutes conducted numerous studies on these issues, the results of which are recorded in the reports of various institutes. Some of them are listed in the references [32–42] and in 3.512 and 3.513.

1 The factor that has a decisive influence on the accuracy of the hit is the dynamics of the homing processes, which depends on many quantities besides those listed. - Note ed.

2.55. Types of energy
When explaining the principle of the homing method (2.511, Fig. 35), we proceeded from the passive determination of coordinates using radio direction finding, in which the target emits high-frequency electromagnetic energy. But you can use other types of energy, if they manifest themselves in a spatial field.
As is known, stationary (near) fields and radiation fields (distant) are distinguished. In principle, all fields are applicable for determining coordinates in homing, but it should be noted right away that the methods used so far in practice were mainly based on the use of radiation fields. Here you need to give an overview of both fields.
2.551. Stationary fields. These include vector and scalar fields.
2.551.1. Vector fields. These, in turn, include:
2.551.11. Electrical
2.551.12. Magnetic
2.551.13. Gravitational field.
Common to all of these fields is that the field strength decreases with increasing distance from the place of its occurrence, regardless of whether it is a potential or vortex field and the direction of the lines of force in that place. If it is possible to establish in space the direction of the greatest change in the strength of the field, then it leads to the source that creates the field. In practice, the matter boils down to the fact that the controlled object should move in a potential field (electrostatic field and gravitational field) in the direction of the field vector, and in a vortex field - along the normal to the field vector. As for the gravitational field (gravity field), then every body falling to the ground is “homing”. Apparently, there are no prospects for the technical use of the attractive forces of other celestial bodies in the near future. But in astronautics this moment plays an important role, since a special homing device is not required here. In electric and magnetic fields, in contrast, forces

attraction are so small that they are practically not able to have a direct impact on the controlled object. To use these fields, highly sensitive devices are needed, but until now no practical solution to the problem has been found.
2.551.2. Scalar fields. In principle, the scalar fields (for example, temperature, density) can be applied to the following reasoning: if the scalar value of the potential at a given point is cp, then the field can also be represented by the vector P = grad cp, which can be considered as a vector of the potential field.
As an example of the practical use of such a field, mention should be made of an attempt to pursue an airplane in a trail. At the same time, shells or anti-aircraft missiles were equipped with homing systems that respond to the content of water vapor (condensation band), to the content of CO, or to ionization of exhaust gases. As far as the author knows, all these attempts did not give satisfactory results, since the resulting effects are too weak to be able to be used quickly enough by on-board devices.
2.552. Radiation fields. This refers basically to the same types of radiation that were listed in section 2.331 for transmitting telecontrol commands. We are talking about electromagnetic and mechanical (acoustic) types of radiation.
2.552.1. Electromagnetic radiation. It is subdivided as follows:
2.552.11. High-frequency (radio) radiation in the frequency range from about 105 to 1011 Hz (A = 3 km — 3 mm); basically, the frequency range is used in the range of about 3 • 107 - 3 • 1010 Hz (A = 10 m – 1 cm).

2.552.12. Thermal (infrared) radiation in the frequency range from about 1012 to 3 • 1014 Hz (A = 0.3 lsh - 1 micron); since photocells are used to receive this radiation, the frequency range currently used is limited to frequencies above 0.85 '1014 Hz A = 3.5 microns) [48].
2.552.13. Light is approximately 3 • 1014—7.5 • 1014 Hz (A == = 1 ... 0.4 microns).
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2.552.2. Mechanical (acoustic) radiation:
2.552.21. Sound, 16-16 • 103 Hz; practically the frequency range from about 50 Hz to 1 kHz in air is mainly used.
2.555.22. Ultrasound, from about 2-104 Hz to a few megahertz; applied under water.
In the table. 7 (2.33) these frequency ranges are placed in columns 12-15.
In principle, one could, just as in the case of stationary fields, determine the change in the intensity of the radiation field and use this effect for homing. It is much simpler, however, to determine the direction of the beam, that is, to do what is called sighting in optics, and direction finding in radio engineering. Any automatic direction finder is, in principle, applicable as a homing system.
2.56. Location of energy source
Possible telecontrol methods have already been listed (2.412.4, Fig. 27).
2.561. Passive method. If the target creates a radiation field that has sufficient power at the distance necessary for homing, then the homing device consists only of a directional receiver, that is, a device that responds to the field and allows you to determine the direction of the field vector (2.521) or the direction of radiation (2.252). This also includes pointing to light sources, sources of thermal radiation or noise, as well as to radio transmitters of all types. The problem is solved quite simply if the energy source serves specifically the purpose of guidance. In this case, communication with the target or object to determine their coordinates (see Fig. 27) can be carried out most efficiently by choosing the appropriate frequency, modulation, radiation diagram, etc. (example. 3.6). For homing combat weapons, this opportunity disappears, and you need to look for ways to use the energy radiated by the target itself (the enemy). Examples: ship propeller noise, thermal

radiation from industrial facilities, enemy radio transmitters, etc.
2.562. The active method. If the target does not create a field that could be used, then it can be irradiated from a managed object. In this case, the determination of the coordinates of the target for homing is carried out on the direction of the reflected rays. A prerequisite for this is that the target in its ability to reflect rays should be very different from the environment. The types of energy applicable in this case are in principle the same as with the passive method. When using stationary fields (2.551), active self-guidance is also possible in principle, and instead of reflecting the rays, there will be a field perturbation that can be measured for electrostatic fields, for example, by capacitive methods. Examples of active emitting devices: airborne radar stations, infrared spotlights,
If the sources of energy for irradiating the target are not on board the controlled object, but in some other place, then they talk about a semi-active method.
2.563. Semi-active method. The “transmitter” using this method will be relatively complex, bulky and heavy. If the transmitter is installed on board, it always obeys the general limiting requirements for on-board devices regarding size, weight, energy consumption, etc. At the same time, when installing the transmitter in another place, a large radiation energy is necessary, since the removal of the location of the energy source to the target is almost always greater than the distance to it from the managed object. As a result of this, the relative level of interference is also higher, since the field strength at the target’s location during the guidance time remains relatively small, while with a purely active method the field strength increases when approaching the target.

until it is possible to locate the target from the point of location of the radiation source. From the above considerations, it becomes clear that the semi-active method can be used only in special cases1.
A special case of the semi-active method is the use of daylight homing systems, in which the sun is the source of energy for natural illumination of the target. In practice, such homing installations (as well as target designation, for example, television devices) are classified as passive.
2.564. Indirect method. In addition to the methods we have examined, some other special applications are possible.
2.564.1. Relay transmitters. If the “target” is specially equipped to drive homing objects, then this equipment may consist of an energy source (transmitter) located on the “target” and emitting only for “interrogation”. The response signal can be sent directly from the object itself or from another place. Examples: remotely-switched landmarks or radio beacons.
2.564.2. Specially placed transmitters. If you need to aim at a target that does not emit itself, and at the same time it is impossible to search by the active method, then in some cases you can first provide the target with a radiation source, and then locate it using the homing system. Examples: emergency marine transmitter, undercover transmitter.
2.57. Application area
Combinations of the listed types (2.55) and locations (2.56) of energy sources provide many theoretical possibilities, which, however, far from all can be realized. Already mentioned, that the methods
1 Currently semi-active method is widely used, and as "transmitters" used interception station and fire fighters, ground stations angular tracking, etc. - Ed...

based on the use of stationary fields (2.551), to date have not yielded practical results. The reason for this is that the capture range (2.52) of technically feasible devices is for the most part only a few meters. This order of magnitude is practically not of interest for homing purposes, but it is quite applicable for automatic fuses, etc. (2.62).

Homing devices based on the use of radiation fields (2.552) have very different applications. The practical reach of capture ranges from a few hundred meters (acoustic) to hundreds of kilometers (passive direction finders). The magnitude of the capture angle to a large extent depends on the specifics of the devices used; if it can be 10 ° –30 ° for high-frequency devices, then optical devices have capture angles of several degrees.

Regardless of these differences, due to the technical parameters of individual devices, there are limitations on the possibilities of application due to the nature of the propagation of radiation of a particular type of energy. The influence of the environment in which the propagation takes place, the influence of lighting conditions and weather on the possibilities of using homing systems are schematically summarized in table. 8.

From the table. Figure 8 shows that installations operating at high frequency are the most versatile. This fact becomes even more important in connection with the fact that the ranges and capture angles achieved by these installations are perhaps the largest of all known methods. Their disadvantage is the relatively high cost, especially in relation to active homing systems.
For acoustic devices, the disadvantage is that sound has a low propagation speed, especially in the atmosphere. In addition, the sound interference created by the controlled object (for example, engine noise and flow noise) is eliminated with great difficulty, and often this cannot be achieved at all (see 3.513.3).
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Table 8
FIELDS OF APPLICATION OF SELF-HANDING INSTALLATIONS
The most important range Possibilities of application
in the atmosphere
Type of energy frequency, Hz wavelength at night during the day in fog in RAIN and snow under water in interplanetary space
High-frequency radiation (30—30000) • 10e 10 M - 1 CM + + + + +
Infrared radiation (30-300) 1012 10-1 MK (P) + + +
Light (300-750) 1012 1-0.4 microns (11) + - - - +
Sound 50 — about 1000 6-0.3 m p p p P +
Ultrasound SL 1 word about 10-3 cm + + + - + -
Note. P - passive method: +? active or passive method; - not applicable; () is applicable to a limited extent.
During World War II, installations of all these categories developed. They are discussed in detail in 3.34 and 3.513.
2.6. EXECUTION OF SPECIAL COMMANDS
In the preceding paragraphs, we repeatedly spoke about the initiation of individual processes associated with the transition from one state of movement to another, for example, from telecontrol to homing (2.14, 2.54), from flying with a running engine to further flying with the engine turned off (2.311, 2.43 ) and t. d.
this case also relates excitation processes which must occur while achieving its purpose remote controlled object (or slip), first excitation processes of ignition of explosive vesche Twa to remote controlled or
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autonomously controlled and uncontrolled charge carriers (1.22).
The last task is primarily due to the fact that even the most advanced control systems do not allow to increase the accuracy of hitting above known boundaries, especially when pointing at fast-moving point targets (1.342.2).
Although in this case we are not talking about the immediate tasks of telecontrol, nevertheless, the statement of the problem and possible fundamental solutions are outlined here. This is done because of the aforementioned connection, and also because the technique of this kind of “executing special commands at a distance” has much in common with the remote control technique.
2.61. Types of execution of special commands
By analogy with the types of control discussed in Section 2.1, you can fundamentally distinguish:
2.611. Execution of special commands without external influences.
2.611.1. According to the preliminary and unchanged in the subsequent installation (according to the “program”), for example, a remote temporary fuse.
2.611.2. Depending on the motion parameters or on the values determined on board a moving object, for example, using track meters (turning off the V-2 engine, see

3.522).
2.612. Execution of special telecommands. The method of separate commands described in Section 2.311 is suitable for implementing the method for executing special commands at a distance. For the functioning of the systems (see Fig. 10, a, 11, 12) it does not matter whether the command is designed to rearrange the governing bodies or to initiate other processes. Therefore, all of the command lines listed in 2.33 can be applied. Generally speaking, they will use approximately the same devices for transmitting special commands as for remote control.
Examples: TV ignition of the charge of planning bombs at the time of flight over the target; smoke cover 7 *
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Chapter 2 with a
curtain of explosive carrier B-4 using a command over the radio channel (3.511.11, 3.514.1, 3.526.12).
2.613. Automatic execution of special commands. The command to initiate the desired process is determined by the position of the moving object relative to the "target". This case is the most important type of execution of special commands, especially if we bear in mind the ignition of explosives on charge carriers. In this case, special equipment is usually required. This equipment, which is not exactly called a "TV fuse," and the corresponding methods should be considered in more detail in the following sections.
2.62. Methods for the automatic execution of special commands
2.621. The main provisions. The principle of operation of the equipment for automatically executing special commands can be most clearly explained by comparison with homing devices: while the latter have as their task the creation of control commands (with subsequent transfer to the control bodies) depending on the angular position of the object relative to the target ("target deviation", 2.52), the former must issue a command, having passed a certain distance between a moving object and the target. Hence the term remote fuse.

Since in this case we are talking about the approximation of a moving object to the target, the term proximity fuse is also used. Both terms in the German language are still, as far as the author knows, are applied without a strict distinction between their meaning [1, 15, 25, 45.1, 46–49] 1.

But since in this connection one can distinguish two different operating principles (and two different statements of the problem), the author proposes the following classification in order to unify terminology:

2.621.1. Remote fuses. To them

1 In English and American literature, only one term is used: Proximity fvse.

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fuses that ignite a charge when a predetermined distance is reached (or a distance due to the sensitivity of operation of the device, see 2.631).

2.621.2. Proximity fuses. These include fuses that fire when the object passes at a minimum distance from the target (or vice versa) (2.632) 1.

2.622. Forms of energy. For the operation of automatic fuses, as well as for homing devices, you need a field created directly or indirectly by the target. However, instead of determining the angular positions of the target (direction finding), in this case, the determination of distances is used, while in principle the same forms of energy are suitable as for homing purposes. Enumerating them will be redundant, since the systematization given in section 2.55 can be the basis. See also tab. 7, columns 16-19.

However, for the operation of automatic fuses, it is practically possible to use static fields (2.551) in simpler ways, since in this case we are talking about much shorter distances and, therefore, greater “field strengths" than for homing devices.

2.623. The location of the energy source. The conclusions made in section 2.56 for homing devices are also valid here; therefore, it is possible to distinguish between fuses operating by active and passive methods.

2.63. Automatic

fuses2 2.631. Remote fuses. If we turn to the consideration of the fields in sections 2.55 and 2.622, then you can

1 Both of these types of fuses in our literature are combined under the name "non-contact fuses." The term "fuse" in the domestic literature refers to fuses that fire after a certain time, that is, after a certain distance after the launch of the projectile. - Note ed.

2 The term “fuse” is used most often. Of course, other processes can also be excited (see introductory remarks to section 2.6).

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note that reaching a certain predetermined distance between a moving object and a target corresponds to achieving a certain field strength at the measurement point (“Receiver”) located on a moving object.

As an example, we can mention the passive acoustic remote fuse “Maize”, which is triggered when a certain pressure of sound waves on a microphone is reached (It was used in the X-4 rocket, see 3.514.23 and 3.524.1.)

Instead of directly measuring the field intensity, the influence of the field perturbation can be used.

This method is used, for example, with capacitor remote fuses: operation in this case occurs if a body with high conductivity (or dielectric constant) is placed in the active electrostatic field, due to which the capacitance between two capacitor plates (for example, between the shell of the projectile and the pin) is changed . For these and many other devices for presetting the exact distance, triggering occurs when the minimum perceptible change in capacitance is achieved.

Instead of field strength, you can use the field potential. Example: fuse triggering at a

predetermined barometric height1 (scalar density field, 2.551.2).
Finally, to determine the distance to the target in the presence of radiation fields, the path of the beam between a moving object and the target and vice versa can be used. As an example, we mention the possibility of using an electric meter of low heights, operating on the principle of a sawtooth frequency modulation [1] (3.514.21).
2.632. Proximity fuses. According to what was said in 2.621, this is understood to mean automatic fuses, the operation of which occurs when the moving object is at a minimum distance of
1. Such a device, strictly speaking, refers to a different type of fuse. - Note ed.

from the goal. Fuses of this type play a particularly important role in the use of remote-controlled and homing weapons, since a direct hit that triggers shock fuses, especially when it comes to hitting fast-moving targets (anti-aircraft missiles, fighter shells), can only be counted on some special cases. Of course, such automatic fuses can be used in unguided shells or other flying bodies, in mines, etc.
To solve the problem, in principle, the same effects apply as for remote fuses (2.631), if the operation is made dependent on a change in the parameter used .

~ c-const
The trajectory of a moving object
2.632.1. Change in field strength. Since at the time of the minimum distance (r0, see Fig. 38) the intensity of the target field in the place of the moving object reaches its maximum, this moment can be used
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to fire the fuse. The reason why this method is rarely used practically is because the spatial sensitivity diagram (for example, the radiation pattern of the antenna device of the transmitting and receiving parts) is not uniform enough to confidently avoid the false max-mind caused by this circumstance.
2.632.2. Change in travel time. Since the travel time of the beam between a moving object and the target and inversely proportional to the distance r, it is possible to use the moment of passage of its minimum value to fire fuses. This most frequently used method when using the Doppler effect allows you to construct simple equipment: the Doppler frequency is proportional to the speed of approach between the object and the target v and passes at z = r0 through its zero value, with a decrease and by
(dv \ the
next increase | ^ -j occurs quite intense Example: an active high-frequency fuse of the Kakadu and others approximation (see tables 13 and 3.514.21).
2.632.3. Radiation pattern. The detonator firing at the moment of passing the object past the target can be achieved due to the fact that the diagram of the receiving device (and, with the active method, the diagram of the transmitting device) is directed perpendicular to the direction of movement (disk-shaped diagram). As an example, we can point to the Trichter active high-frequency remote fuse (3.35, 3.514.21), where a combination of the Doppler effect and a disk-shaped diagram was made [49].
Since devices of this kind are triggered by quantities characterizing the movement of an object relative to the target, they can also be used to excite the necessary processes even when the object is stationary and the target is mobile. Example: “Tiffliger-fall” - a device for actuating firearms on the ground when flying a target [49]
(3.514.3).
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## 2.7. SPECIAL PROBLEMS
In this section we will see how many problems must be solved in the design and development of telecontrol devices and installations. The considerations presented in this chapter are just some of the recommendations that are given as supplements to the fundamental provisions set out in the previous sections, but which to a certain extent are of general importance for many chapters.
### 2.71. Transmission Type Selection
Considerations regarding the scope that have already been expressed in connection with the consideration of homing devices (2.57, Table 8), in principle, also apply to the transmission of telecontrol signals and other information (for example, to transmit target coordinates using the target designation method, according to 2.412.3 , Fig. 27.6 and 32). In most cases, the determining factor is the required range.
If we dwell on the most important communication line - radio links (2.331.11), then the first question will be the choice of transmission frequency. In this regard, you can give approximately the following recommendations:
a) If there is “optical visibility” between the transmitter and the receiver (it is assumed that there are no conductive or dielectric obstacles between them), then the frequency range between 30 and 30 000 MHz (ultrashort, decimeter and centimeter waves) should be preferred.

The shorter the wavelength, the smaller the dimensions of the antenna system, the easier the beam of the radiation pattern is achieved (cf. 2.73). However, it should be noted that in the practice of pulsed technology only waves of the decimeter and centimeter ranges are used. For the transmission of information over the communication line between the Earth's surface and interplanetary space, the frequency ranges between 300 and 10 000 MHz (A = 1 m to 3 cm) are taken into account mainly (26.1).
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b) For communication near the earth's surface in the absence of “optical visibility” at a short range (several kilometers), ultrashort waves can also be used. (Example: FKL-8, see, 3.511.11 -
3.526.12.) In addition, medium waves or, for long ranges, short waves from 300 kHz to 30 MHz can be used (3.6).
c) Long waves (range 100 kHz) are used only in special cases, for example: passive exit to the target, which is a long-wave transmitter; Decca Navigation Hyperbolic System; NT system (3.511.15-3.526.23). Sound and ultrasonic transmission is common only in systems operating under water [14, 103], except for passive automatic fuses (2.63, 3.514.23 and 3.513.3).
On the one hand, transmission over a wired communication line (2.332), in contrast to radio and other radiation-based communication lines, has a significant advantage in terms of noise immunity (cf. 2.72). On the other hand, the maneuverability of a controlled object due to a wired or cable connection, of course, is somewhat limited. A wire communication line for flying objects1 was nevertheless successfully used with a two-wire line length of up to 30 km (3.511.2, 3.523.1 and 2, 3.524.1).

2.72. Interference immunity
An extremely important issue for the practical application of telecontrolled objects is the high susceptibility of radio links to interference.
When the first interplanetary ship to the moon starts, then through an international agreement it will be possible to ensure that there is no interference in the frequency range used to control and navigate the ship. The situation will be different in the case of the use of remote-controlled weapons, in relation to which -
1 For objects with subsonic flight speed. - Note
ed.

It must be borne in mind that the enemy will try to interfere with the transmission of telecontrol signals. Such derivative interference can be of two kinds: on the one hand, it is possible to interfere with the transmission of commands in general or only interfere with their correct execution, on the other hand, it is possible to intervene in the control of the object and give other commands than those issued at the control point.
An effective way to prevent the influence of such interference is to use a wired communication line (cf. 2.71, 3.523), however this method is acceptable only in special cases. The following brief remarks relate to radio links. They are valid both for transmitting telecontrol commands themselves and for reverse transmission using the target designation method.
First of all, it is necessary to make it difficult for the enemy to detect such a transmission. There are the following ways for this:
a) reducing transmission time to a minimum;
b) reducing to the permissible minimum the width of the radiation cone (by means of directional tracking antennas on the side of the transmitter);
c) a decrease in transmitter power (this position contradicts the requirement to create a large field strength at the receiver);
d) the use of masking modulation;
e) frequent change of the operating frequency, etc.
To reduce the effectiveness of interference caused by the enemy, the following measures are taken:
a) Directional reception at a telecontrol facility. In most cases, it is necessary to reckon with the fact that the interference comes from the target itself (or from its immediate vicinity). Since the direction of the object - the control point changes during movement, this largely determines the requirements for the radiation pattern of the receiving antenna. The radiation pattern should have the smallest possible reception “front” and not sharply directed reception “behind” (relative to the direction of movement).
b) The input stages of the receiver are calculated for a relatively large amplitude signal. In this case, the operation of the receiver is not disturbed by a simple

“locking” when, for example, an interference transmitter with a rocking setting or a bandpass interference transmitter is operated.
c) Increase the selectivity of selection means. As far as possible, selection should be done several times (high-frequency, low-frequency and at an intermediate frequency).
d) A good match is achieved between the frequencies of the setpoints during pulse reception, so that the loss of individual received pulses does not interfere with the operation of the system.
e) The use of devices that make it possible to distinguish a useful signal from an interference signal (for example, in the direction of incidence of the beam).

In the first time after the start, there is practically no interference, since, firstly, the useful field strength is large, and secondly, the enemy has not yet managed to detect the attack. Only as the telecontrolled object approaches the target can they be expected to appear. The occurrence of a specified excess of the interference level above the signal level can be used to initiate certain processes, such as switching from telecontrol to autonomous control (for example, further movement is carried out in a straight line), switching to automatic homing using a different type of energy, or to automatically aim at the transmitter interference (cf. 2.75).

2.73. Antennas

Some fundamental comments on factors influencing antenna design have already been made in previous sections. On remote-controlled objects, especially on remote-controlled flying objects, which are small in size, the possibilities for installing an antenna are very limited. In addition, changes in aerodynamic properties due to the outdoor installation of antennas are usually unacceptable. It is often necessary to place the antenna so that it enters the structure of the object as one of its elements. All this speaks for the use of small antennas, and therefore, very short waves (2.71). The most important forms of antennas are [26.5, 49.71, 110]:



a) a reflective installation with a dipole or waveguide antenna system;

b) a dielectric emitter;

c) short rods in the quarter-wave and dipole antenna systems or in the “Yagi” antenna system;

g) slot emitter;

d) a planar emitter.

The ultrashort-wave antennas previously used on aircraft were quite primitive (3.523).

A serious problem is the occurrence of interference and the shielding effect of a gas stream during the operation of a jet engine. This phenomenon created an interference voltage that acted on the input of the receiver and, in addition, caused energy absorption and distortion of the radiation pattern [26.5, 71.97]. Thorough research was conducted on these issues by various institutes. Unfortunately, the author does not know the detailed results of these studies. It was found that due to the special lining of the jet nozzle and the addition of impurities to the fuel, the Walter engine has minimal ionization of the gas stream.

A significant difficulty also lies in the danger of electrical breakdown when an aircraft enters the low atmospheric pressure region; This is especially true for high-altitude rockets and interplanetary spacecraft. To avoid breakdown at high voltages, the antenna maintains a constant pressure in the sealed part of the high-frequency system, as is required for high-altitude electrical devices (2.74).
2.74. Design The
practical creation of telecontrol installations presents numerous special requirements for the technique of performing instruments and installations (mainly instruments and installations used for flying objects are considered), some of which are given here.
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Without exception, all parts of the installation must first of all satisfy the general requirements that apply to airborne on-board devices. The following must be ensured:
stable operation of the plants in the temperature range from –60 to +60 ° C (otherwise, it is necessary to ensure the heating of the device or that part of the volume where the device is located);
altitude corresponding to a given field of application (in some cases, the housing is made airtight and overpressure is created in it);
vibration resistance (the normal value of the acceleration amplitude during vibrations is approximately ± 5 d) \ resistance to accelerations (the normal value of accelerations is approximately 8-12 d, for fired devices, more than 100 d) \
the independence of the installation from the operating voltage within approximately + 15%, if the voltage regulation of the on-board network of the facility is absent;
the most minimal volume, weight, energy consumption; full automation of the operation of devices on board the remote-controlled object after its launch (on the resettable object already during the approach); maximum reliability in work.
To guarantee the satisfaction of the above requirements, it is necessary to ensure a thorough test of on-board devices and installations before starting, and during testing conditions should be created that are closest to those in which the equipment operates on board the object.
When developing the design of devices, special attention needs to be paid to maintaining the constancy of frequency under the above conditions. To this end, it is necessary to ensure: stability of the design of the elements that determine the frequency, control by means of a crystal (difficult in relation to changing frequencies), preliminary switching on the incandescent lamps, accurate automatic adjustment, temperature compensation, stability of the operating voltage, etc. (see [97] , 3.511.12, 3.512.1).
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2.75. Transition from one type of control to another with a combined method
This feature has already been mentioned several times. The object is controlled during its movement to the target by various methods (2.14, 2.54, 2.72). The following methods are available for moving from one type of control to another.
a) The moment of transition can be set in advance (time program, track counter, altitude switch, etc.), the transition can be carried out by transmitting a special telecommand (2.6).
b) The transition can occur when a certain state is reached that is “pre-arranged” on board the controlled object, for example, the passage of a marker transmitter (3.6), capture of a target or passage of a certain installation angle by a homing device (2.54), interference with telecontrol (2.72).
c) In both cases, it is necessary to decide in advance whether to return the devices to their original position after the disappearance of the factor that caused their switching, or to save a new position (using a relay with a latch).

In the absence of telecontrol signals, it is possible to provide for terrestrial and marine objects the automatic sending of the Stop command (3.511.11). For airborne objects, it is necessary to provide for a certain flight mode (for example, a straight flight or saving the last command).
The method of prohibiting the execution of a command until receiving a confirmation back or before developing another command (3.526.21), used in the Zeringen telecontrol system, is not applicable for controlling airborne objects.
2.76. Target selection
A particular problem in some cases is the requirement of aiming at a well-defined goal in the presence of several similar goals. With the visual alignment method (2.412.11), the correct solution is
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tasks depends only on careful observation of the operator or on the appropriate visibility conditions. The situation is similar when controlled by the television method (2.412.31), if the received image is clear enough. With the panoramic method (2.412.2), it is also easy to pursue a specific goal using a panoramic image on the screen, if we are talking about movement in one plane (ships). On the contrary, for airborne purposes (for example, aircraft formation), difficulties arise in obtaining the correct readings in azimuth and altitude. Similar difficulties occur in the case of radio or infrared direction finding (2.412.12 and Fig. 32). In order to be able to distinguish targets in these cases, it is necessary to use range data, as well as, under certain circumstances, relative speed.

Homing most often occurs on the energy “center of gravity” of the radiation of the target group, at least with active and semi-active methods, while with the passive method, guidance is carried out for the most part only to a specific “transmitter”. The selection of one predetermined target from the set of identical targets that are in the field of view of the homing installation is practically impossible. When a homing object approaches the formation of airplanes, gradually those that have maximum reflection are selected from targets inside the angle of capture of the homing device. With the introduction of the “installation angle”, as indicated in [96], this process, however, has nothing to do.

# CHAPTER THREE

# EXAMPLES OF COMPLETED AND DESIGNED SYSTEMS

If in the previous sections an attempt was made to state the theoretical foundations of telecontrol, now it is necessary to move on to practical issues of telecontrol technology. After a brief review of the history of the development of this technique (3.1) and some comments on the issue of “model management” (3.2), a review will follow in the form of tables relating to samples of German remote-controlled weapons and related devices
(3.3), as well as a summary table of American and English developments in this area (3.4). Section 3.5 contains individual data and a brief description of some German telecontrol systems related to the period of World War II, and finally, it provides a particularly interesting example of the further development of automatic control (autonomous control and homing): the flight of an American transport aircraft across the Atlantic Ocean in 1947 year (3.6). It should be noted that the individual details and data given in sections 3.3 and 3.5 do not pretend to be accurate, but give only the correct idea of the principles of operation of devices and the order of quantities. This is due to the fact that some of the small amount of material available to the author contained conflicting data and, in addition, over the past eight years, of course,

## 3.1. HISTORY OF THE QUESTION

The idea of controlling the movement of an object at a distance arose at a time when the technique of electric communication in general appeared, except for mechanical





impact on the controlled object through a cable or other type of connection. In telecontrol, as well as in electrical communication technology, the transmission of control signals by wire existed first of all, therefore, in the first experiments on telecontrol of cars and ships, command transmission via a wire communication line was used [24, 53]. So, already several years before the First World War, the Siemens and Halske company developed a telecontrol system that provided control of a crewless firewall when it was aimed at a target from the coast or uterus ship. In this case, the transfer of commands was carried out by cable, which was unwound from the drum of the firewall during its movement. The fact that this method was correct is evidenced by the fact that the NYK system, developed in the Navy in 1942-1944, acted in exactly the same way.

Since the possibilities of wired communication between the control point and the remote-controlled object are too limited, already at the dawn of the development of remote control experiments were conducted with wireless transmission of command signals. Even before 1914, a number of wireless control designs were proposed, and perhaps the first such design was the system proposed by X. Wirth (Nuremberg), who also used the coherer as a receiver. The Rover – Mauraher system also dates to this time. This system was intended for wireless remote control of aircraft: airships, airplanes, air torpedoes [24]. However, much earlier appeared work on wireless exposure at a distance to moving objects. As an example, we can name patent No.

34845 “Control of a torpedo using electric waves”,
In military affairs, satisfactory practical results were obtained only when using electronic lamps in receiving devices. However, until 1918, transmitting devices operating on the spark principle were used.
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By the beginning of the war of 1914, the Commission for the Testing of Technical Communications, chaired by prof. M. Wien in Jena began research in the field of telecontrol. This commission has already thoroughly dealt with issues of the practical use of telecontrol systems, such as range, the possibility of creating interference, reliable operation, etc. Since significant difficulties in the remote control of unmanned aerial objects soon became apparent, they limited themselves to developing systems for controlling marine objects.
In 1914-1915, thorough research was conducted on the wireless control of ships, first from the ground (Lake Myggel, 1914-1915), and then from an airplane (Travemunde, spring 1915). After the investigated methods, in principle, paid off, further development and testing were entrusted to the naval forces (Inspection of torpedo business, Kiel, 1916-1918).

The path that Birnbaum, Droisen, prof. Pirani, prof. Pungs et al. Led primarily to a combined method. The control signals sent from the aircraft via a radio line were received by the receiver on land and transmitted using a cable according to the Siemens method to a controlled boat (the speed of the boat was 60 km / h, the explosive charge weighed 750 kg). In some military operations in Flanders and Courland, cables up to 50 km in length were used (it is interesting to compare with the system proposed in Crocus, 2.333, approximately in 1942). Later, the direct transmission of commands from an airplane over a radio line to a remote-controlled boat was also tested [24]. Research conducted during the First World War by the German Navy,
1 “Hesse”, together with the Blitz tender belonging to him, was intact in the port of Libava in 1946-1947 and was
apparently exploited by the Russians.
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In France, during World War I, work was also carried out in the field of radio remote control of marine objects. The first tests (Abraham Bloch, Dolme-Dean) date back to 1917, and the method of transmitting individual commands with a step finder (2.311.21) was used [53].
We should also mention the experiments in the field of telecontrol conducted by the Austrian Schmidl of Graz, who from 1928 to 1935 experimented with mail missiles; while remote control commands were transmitted by radio and using infrared rays [9].
How far the development of telecontrol technology in Germany has gone by the beginning of the Second World War can be judged by the so-called Siemens pair, which was demonstrated in Peenemuende on May 17, 1940. The Ju-52 unmanned aircraft remote control equipment kit was developed by the Hackenfeld Aircraft Instrumentation Plant. The Ju-52 unmanned aircraft in the full sense of the word was telecontrolled from the accompanying aircraft: according to the commands given, it took off, gained altitude, made turns, descended, went to land, and included braking during the run [25].
During the Second World War, a large number of remote-controlled weapons appeared in Germany, which were developed by industry on the order of three types of armed forces. However, of these, only a small part of the structures came to the front in large quantities. In most cases, the development of remote-controlled weapons was based on work related to missile research, so the foundation in Peenemuende in 1936 of the military and airborne testing institute was of great importance (3.522). Section 3.3 contains the systematics of samples and projects of remote-controlled weapons, section 3.5 contains some tactical and technical data and a brief description of the most important samples. The data and description of the samples are given with the accuracy with which they were known to the author or became known to him from the press.
In the United States, the development of remote control technology proceeded in a similar way, since the problem of creating a jet engine also stood at the first stage.
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for managed objects. These works were primarily carried out by the Guggenheim Aviation Laboratory of the California Institute of Technology (GALG1T) 1 organized in 1936. In December 1944, the first model of a long-range missile “Private A” with a thrust of a jet engine of 453 kg was tested in California in California. The model flew about 17 km [9]. The very first tests of the German, fully stabilized A-3 long-range missile with a propulsion engine of 1.5 tons (3.522) took place in December 1937 in Greifswalder-Oye. At the third shooting on October 3, 1942 in Peenemuende, the A-4 long-range missile flew 192 km [11]. In the postwar period, based on the work of the

institute in Peenemuende and with the participation of its employees, the development of jet weapons in America made significant progress.
Unfortunately, very little attention has been paid to literature in the field of telecontrol. The main place is devoted to work on engines [9, 10]. This is obviously explained by the fact that the authors themselves are not well aware of telecontrol issues. Section 3.4 summarizes data on English and American models of remote-controlled weapons.
In the 30s, scientific research societies of jet technology were founded, as well as astronautical societies in other countries. In September 1951, in London, 15 such societies merged into the International Federation of Astronautics (IPA) [9]. The range of issues that these societies deal with also includes telecontrol issues and issues related to this area of technology. This can be judged by the publication of the book “High-frequency technology and interplanetary flights” [26], published by the circle “High-frequency technology”, headed by Dr. R. Merten. The work was prepared in connection with the fourth annual congress of the German., Society for the Study of the Universe ”(January 1951, Stuttgart).

1OALCIT - abbreviated name of the laboratory: Guggenheim Aeronautical Laboratory of the California Instituto of Tehnology. - Note ed.

3.2. MANAGEMENT OF MODELS
Section 3.1 and the following sections discuss the application of
technology. telecontrol is mainly for military purposes (excluding postal and research work), while telecontrol of moving models of all kinds covers many other areas: from the manufacture of innocent toys and models in amateur and novice societies of various branches of technology to scientific research of processes of all kinds on moving objects .
If there is little specialized literature on telecontrolled weapons, due to secrecy, then there are a number of published works on telecontrol systems for models of moving objects and especially aircraft models [58, 59, 74–84, 88–90].
Three years ago, Germany again began the activities of amateurs in the field of telecontrol. The initiator of this is the German flying club, which as part of its committee of flying models has created a special section of remote-controlled models and holds competitions [78, 85–87].
Since radio remote control requires a radiating transmitter, the operation of which is subject to control on the basis of the law of January 14, 1928, a special permission of the German postal department is required. This department has established for remote-controlled models that are manufactured by amateurs, the transmission frequencies used for ordinary technical, medical and scientific purposes [78, 85, 86]:
13 560 kHz + 0.05%
27 120 kHz + 0.6%
465 MHz + 0.5%
Antenna power up to 5 e / ha1. In the USA, in addition, the frequency of 52 MHz is used [75], which has the advantage over the frequency band of 13–27 MHz, which requires smaller antennas.
1 Published in the Bulletin of the Ministry of Post and Telegraph of And April 1953.

Remote control devices installed on board the facility are primarily distinguished by low cost. Of the large number of receiver circuits available
. 39. Scheme of a small-sized super-regenerative receiver for single-channel transmission.
Fig. 40. Schematic of a small-sized receiver with a resonant relay.
only two circuit diagrams will be considered, which have been published in a number of special journals [75, 78, 81]; similar schemes are also contained in the sources [79, 80, 82, 88, 89]. In fig. 39 shows a diagram of a super-regenerative receiver for a single-channel-

transmission at a frequency of 52 MHz with the use of an ultra-miniature gas-filled triode RK-61. This receiver is primarily distinguished by its low weight (without a battery, it weighs 60 g, with a battery - 200 g) and allows you to control, for example, relays for multiple individual commands according to the principle described in 2.311.21 (Fig. 13).
The scheme of a three-lamp receiver for receiving three separate commands according to the principle described in 2.311.22, Fig. 12 is shown in fig. 40. The receiver operates with a resonant relay P (headphone system). The resonant relay armature acts on three tabs: gx, gg and g3, the natural frequencies of which are tuned to three different sound frequencies: D, / 2 and / 3. These tabs control the working relays: Pъ P2 and P3. The weight of the receiver without a battery is about 350 g [75].

Tab. 9–13 of this section contain mainly data on German designs of remote-controlled weapons and related individual devices and installations.

3.3. SYSTEMATIZATION OF GERMAN SAMPLES AND PROJECTS OF TELEADOUS MANUFACTURED WEAPONS UNTIL 1945.

They also contain data on related installations of autonomous control according to the interpretation in section 2. In table. 9 and 12 are also mentioned some aircraft radio compasses and related navigation devices, which until now have not been used for automatic homing, but in principle they can be used for this purpose.

Tabli-
tsa



Specific examples are contained in sections:
3.5
3.52
3.511
3.512,3.513 3.514

Table. 9 contains data on both entire systems and individual devices, with the names or abbreviations of the systems located in alpha.

Examples of completed and designed systems in 121
bit order. The remaining tables are constructed in the order of describing the principle of operation of a particular sample.

3.31. General overview

Explanations for the table. 9-13.
3 - ground object;
M - marine object;
In - an air object, an aircraft;
R - rocket;
T - method (device, installation) of telecontrol;
OK - a method (device, installation) for determining coordinates; VTs - a way (device, installation) of reaching the target;
C - homing method (device, installation);
UTs - a method (device, installation) of a target indication;
AB - automatic fuse;

CA - ground army;
Navy - Navy;
Air Force - Air Force;
Railway - German state railways.
AEG -? General Electric Company;
DFS - German Research Institute for Gliding in Ainring;
Donag - Danube Instrument Making Company, Vienna; DVL - German Aviation Testing Institute, Berlin — Adlershof;
ELAC - Electro-Acoustic Society, Kiel and Namslau; FFO - Aviation Radio Engineering Research Institute, Oberpfafenhofen;
G-EA -? Electrical Installation Company, Feldch;
GEMA - Company of electro-acoustic and mechanical equipment, Berlin;
HEV - Henschel Aircraft Plant, Schönefeld (Berlin); HVP - Military Testing Institute in Peenemuende, later also Electromechanical Factories, Karlshagen;
LVP - Air Force Testing Institute, Peenemuende, Karlshagen;
RhB - Rheinmetal-Borzig Company, Berlin;
RPF - Research Institute for German State Post, Berlin;
Staru - Stasfurt Broadcasting Company, Stasfurt; TVA - Torpedo Research Institute Neu-Brandenburg;
P - designed;
V - refinement of the method and preliminary tests;
O - sample (laboratory, experimental);
F - passed the test;
E - adopted;
? - the author does not know;
A is the author.
Table 9
3.3. SURVEY TABLE OF GERMAN SAMPLES OF TELEAPROWATED WEAPONS UNTIL 1945
Species
Name Genus Description of the projectile - Who developed it - Sources of the object or installation of military forces or the company
A R Long-range projectiles ("Aggregate") with autonomous control or remote-controlled telemedicine with a
different jet engine stages of
development SA Management [8, 11]
A-1 R Missile weighing 150 kg, engine thrust 300 kg, stabilization was carried out by means of a rotating flywheel weighing 40 kg CA armament Testing center Kumersdorf-
A-2 R Like rocket A-1, but with a slightly different position of the center of gravity and the location of the gyro-West V [8, I]
osprey CA The same V [8, 11]
A-3 P Rocket weighing 750 kg, engine thrust 1.5 from, stabilized

by means of a gyroscope, had a
radio receiver for receiving a
command to turn on the emergency
engine CA Same O [8, 10, 11]
122
A-4
A-4 b A-5
A-6
A-7
A-8
A-9

A-10
A-9 / A-10
“Adler”
Missile weighing 13 tons, engine thrust 25 tons, the combat name V-2
Like the A-4 missile with a small wing, prototype missile A-9
Similar to missile A-3. A production sample for a preliminary test of the design variant of the A-4
rocket. An experimental rocket tested with various types of fuel.
Like the A-5 rocket, however, it has a small wing. Tested as a sample of the planning missile.
Sample preceding the A-9
rocket. Similar to the A-4 rocket, but with bearing planes. It was also planned a manned version of the
Rocket weighing 87 tons, engine thrust of 200 tons, the first stage for take-off of the A-9 rocket. The
so-called America-Ra-Kete
TV head with an iconoscope and spiral scan of the
SA HVP E image [8 — II, 26, 6 , 71, etc.]
SA HVP V [8, 11]
SA HVP O [10, 11]
CA HVP p [8, 9]
CA HVP V [8]
CA HVP p [8]
CA HVP V [8, 11]
CA HVP r [8, 11]
CA HVP r [8, 10, 11]
Air Force Opt-Berlin V A
123
Name Object type Characteristic of the projectile or installation
“Argus-Project‟ Into a small remote-controlled aircraft, target for the
Army’s anti-aircraft artillery with an infrared homing device using a lens ball (Lensen-Kugel)
“Army E” with an infrared device for controlling airborne weapons with automatic tracking in range
ASV-Halbe CC output device, on a target which is an onboard radar or the onboard transmitter interference
in objects remotely operated crawler wagon 3 (tanks)
B-4 3 Teleuprav yaemy tank for delivering the blasting charge
"Blitz" m tender comprising a transmitting unit for telecontrol "Hessen ^ '
Type vooru- conjugated By forces developed or firm The state of the sources
Air Force Argus; Lorenz
OA Air Force ELAC V [48]
Air Force Air Force Academy, Gatov (Professor Kruger) V [45.1]
Siemens Air Force? [45]
CA - F [46]
CA? F [48, 104]
Navy (Siemens) (E) A
Bodo
BP-20
Brabant
Brig
Burgund BV-143
BV-143B
BV-246
Celebes

Colmar
Ground instrument for Rheinland installation
B
+ Same as Nutter T + OK Ground installation for Rheinland and Kogge systems
Radio receiver for telecontrol to Kogge (UHF receiver)
T + OK Ground installation for Rheinland systems OV ”and‟ Kelheim ”
V Surface torpedo.
relative to three axes with a special device that determines the flight altitude above the water.
Similar to a BV-143 torpedo with directional control from an airplane over a radio line.
A
long-range planning bomb with autonomous control is applicable as an anti-aircraft target.
Installation for creating a directing plane in the Ga-wai system II ”
The receiver of the telecontrol line is similar to the receiver‟ Strasbourg ”, however the cheaper
Air Force‟ Telefunkey ”0 A

Bakham Air Force O [10]
Telefunken Air Force R [47]
Telefunken Air Force F [46, 47]
Telefunken
Air Force O Air Force Blom and Foss O [25]
Air Force Blom and Foss ″O [25]
‟ Blom and Foss ″V [25]
Air Force‟ Telefunken ″O [46]
Air Force SA‟ Friceke ″and‟ Hepfner ″F [46]
Name Object type Characteristic of the projectile or installation
‟ Duckel ″ with Active homing device on the basis of radar
"Detmold" t receiver remote control with a two-wire transmission line commands DC (transmitter worked with "Du .ren"), was used for the bomb ,, Fritz-X "
," Dog "with the Acoustic Passive s device for homing missile "X 4"
‟Dortmund″ t Remote control transmitter or transmitter for transmitting commands at a low frequency via a two-wire communication line for remote control Hs-293
‟Drahe″ ok Reflector ‟Riesen″ in conjunction with a
Duisburg anti-aircraft missile coordinate sensing device t Remote control receiver for low-frequency two-wire command transmissions (to the Dortmund transmitter), used for the Hs-293
Type of armed forces Who did the company develop State of
Air Force RPF? [48] Staru Air Force
F [46]
Telefunken Air Force about [48] Staru
Air Force E [46]
Telefunken Air Force R [47] Staru
Air Force E [46]
Duren
"Dyussel-
Dorf"
"Ebbe"
,, Ehse "
" egerland "
‟Elfe″
‟Alsace ″,,
Emden-Tag ″
Transmitter or transmitting telecontrol unit for transmitting direct current commands via a two-wire communication line for bomb control‟ Fritz-X ″
Transmitter or transmitting telecontrol unit for transmitting direct current commands via a two-wire communication line for controlling an X-4
AV projectile Automatic fuse
for rail mines
T Device for automatically
maintaining the distance between trains on the
OK railway One of the variants of a centimeter radar range (to the Hansa system)
AB Attachment to the airborne
radar for automatic activation of weapons
T + OK Ground installation for Rheinland and Rheingold A and Kelheim systems
Optical homing device that responds to a modulated light source of
the Telefunken Air Force F [46]
Donag Air Force F [46]
Railway Telefun- cap ″? [45]
Railway Telefunken V [45]
Air Force Telefunken O [15]

Air Force Funktral, FFO V [45]
Air Force Telefunken O [47] A
Air Force AEG V [48]
name Type of object features or projectile Fitting
"Emden I" with infrared homing device with a disk to obtain the coordinates in the polar system
"Emden P" is similar to the device "Emden I", but with the disc for direct golnoy coordinate system
"Entsian" p remotely operated anti-aircraft missile wooden structure
E *, Ej, E $ With Walter
E4, e5 engine With Konrad
FB-50 engine UTs Television head with 50-line scan, image scan carried out! with Nipkova’s disk
FB-1000 in 1.000 kg
telecontrolled falling bomb “Voorlie” r Self-guided anti-aircraft missile
F-25 120 kg rocket with swept wing
F-55 470 kg rocket in a tailless construction variant Armed weapons
view Kei forces developed or company Status Sources
AEG Air Force O [48]
AEG Air Force V [48]
Air Force Wood Construction Company “Sonthofen” VF [9, 47] [9] [9]
Air Force Television Company V [48]
Air Force Siemens ”V A
Air Force VBB [9, 25, 95]
Air Force O [9]
Air Force V [9]
128
Fi-103
(V-1)
FKL-8
“Flatter-LS”
“Flensburg”
“Flitzer”
“Franken”
“Fregatte”
Fritz-X
FuG
FuG-101
Self-propelled self-propelled projectile with engine “Ar-gus-Rohr”
Radio remote control system for “V-4”
Remote-controlled planning aircraft for testing television output to the target of the VTs Same as “ASV-Halbe”
M Remote-controlled high-speed
boat
T + OK Ground installation for “ Rheinland oV ”with“ Kogge ”
T
Telemetry receiver of a decimeter-wave range of superheterodyne type to“ Kogge ”(subsequent modification of“ Brig ”)
Remote-controlled armor-piercing falling bomb weighing 1400 kg
General abbreviation for on-board radio devices or radio remote control systems. This designation also applies to command transmission settings over a wired communication line.
OK Radio altimeter with continuous
high frequency change of the
Fizeler Air Force E [11, 25]

Blaupunkt F [104]
DFC V Air Force [39]
Siemens Air Force? [45]
Navy? V A
Telefunken Air Force V A Telefunken
Air Force about [46]
DVL, RhB, GEA E Air Force [25, 30, 31, 97]
Siemens Air Force E
129
Name Object type Characteristic of the projectile or installation
FuG -203 T Aircraft on-board remote control installation with transmitter ,, Kel ”.
FuG-204 T Telecontrol ground installation for “Argus Project” (that is, “Kel II”)
FuG-205 t On-board telecontrol installation for working with the Greifswald transmitter
FuG-206 t Modification FuG-203 for installation on a fighter ( for telecontrol of air-to-air missiles)
FuG-207 On-board telecontrol unit with wired communication line with Dortmund transmitter
FuG-208 Similar to FuG-207, but with
Duere transmitter FuG-230 Receiving radio control receiver Strasbourg"

FuG-230a The same, especially for the Fritz-X
FuG-230b The same, especially for the Hs-293
Type of Kei’s armed forces, develop or company State Sources
Telefen-ken, Optima E A
Air Force Lorenz O A
Air Force Lorenz
RA
Air Force “Telefunken ” V A Air Force “Telefunken” - “Staru” E A
Air Force “Telefunken” F
Air Force “Staru" E A
Staru-GEA E A
- Staru-HFW E A
FuG-232
FuG- 235
FuG-237
FuG-238
FuG-350
FuG-351
FuG-380
FuG-510
FuG-512 ff
FuG-530 ff
FuKE-8
FuKS-8 Radio
control receiver with Colmar receiver
The same, but with the Colbert g receiver.
Remote control receiver via a wired communication line with the Duisburg receiver for Hs-293
The same, but with the Det-Mold receiver for Fritz-X.
Same as “Naxos Z”
Same as “Corfu”
Automatic fuse with synchronous detection
Aircraft on-board remote control for wires with a transmitter “Dusseldorf” (for X-4).
Radio control transmitting unit with the Kogge system Radio control transmitting unit with the Kogge
system
Receiver) Transmitter j
to FKL-8
Air Force HFW About
Air Force Lorenz-Staru RA Air Force Staru
-HFW EA
Staru-GEA F A
Air Force Telefunken E [1]
Air Force Blaupunk E [1]
Air force? ? [46]
Donag — Telefunken
air force F A Telefunken air force V A
Telefunken air force
AT Blaupunt SA F [104]
131
Name Object type Characteristic of a projectile or installation
FuMG ok General designation for radar devices and installations
FZG-76 See. Fi-103
CB-200 glide bombs 250 kg controlled by the gyroscope

"Gayner" With Active acoustic homing device of the torpedo
"Goliath" 3 Wedge, remote-controlled by means of a two-wire communication line
"Greifswald" t control transmitter of radio, like "Kel", but with frequency modulation
"in Gryune ze "Anti-aircraft battery with a remote-controlled anti-aircraft missiles
“G-Schlepper” Brand name for V-4
“Hamburg” C Infrared passive homing device
“Hansa” t + ok Ground installation for “Rhine-land” with centimeter-range radar station
Type of armed forces Developed by Influencer Sources of the
Air Force RhB V 25
Navy Torpedo Commission V 14
CA? E -
Air Force Lorenz OA
Air Force - O [15]
CA F -
Air Force ELAC O [45.1, 48]
Air Force Telefunken R [47]
,, Haze ”
‟ Hawaii ”
‟ Hawaii 1.6 ”‟ Hawaii II ”
‟ Hecht ”
‟ Hesse ”
Hs-117
Hs-293
HS-293A Hs-293B Hs 293D
Guide plane transmitter for‟ Harbor 1.6 ”
Installation creating guide azimuthal plane to control the missile A-4
Completely motorized device for creating the guide plane
Installation for creating the guide plane "Tselebes" on-board installation "Pope-Geist"
Study missile weighing 140 kg
tele marine target
remote-controlled anti-aircraft missile
tele glide bombs -mini AECOM 500 kg engine Walter
same but telecontrol by radio
same but telecontrol by wireline
same, but with TV activity onnoy head "Tokne"
CA "Telefunken" E [46]
SA "Telefunken" E [46]
E [46]
? [46]
RhB V [9]
Navy (Siemens) (E) -
Air Force HFW F [9,10,25,47]
Air Force HFW E [9, 10, 25,
97]
E -
E -
O -
Name Object type Characteristic of the projectile or installation
HS-293H The same but with the Schmidding engine
Ha-294 in Like Hs-293, but with immersion in water
Hs-295 in Like Hs-293, but an increased caliber (2 t)
Hs-296 in Like Hs-293, but with a television head
Hs-297 to the old designation for Hs-117
Hs-298 to a remote-controlled missile for hitting

Gukkepak aircraft in a system for using aircraft that have exhausted their life (for example, the He-177) as a charge carrier (cf. the American Vieri system Willie ")
Isegrim AB Active magnetostatic automatic fuse
Kai T Control transmitter but radio to the Kogge system
Type of armed forces Developed by or company Condition Sources
F [9, 10]
Air force HFW O [9, 25]
Air force HFW V A
Air Force HFW V [9]
Air Force HFW - A
Air Force HFW o [9, 10, 25, 95]
Air Force Various firms E A
Air Force? [46]
Air Force Telefunken F [46]
134
Kakadu
Karte
Kel
Ked 1, III, IV
Kel II
Kelheim
Kirshkern
Klapper
Kogge
Non-proximity proximity fuse, based on active high frequency method
Prefix to the Klap-per sensor for control in rectangular coordinates
Command ultra-short-wave radio control command transmitter with accessories (modulator, command sensor)
On-board radio control transmitting installations with Kel
transmitter Terrestrial radio control installation MO-12 "
Terrestrial radio control transmitting installation
. See Fi-103
Kogge command sensor in various design variants.
Radio control system in the decimeter wave band. The system includes universal devices and installations of
the Donag Air Force F [46, 47]
Telefunken Air Force V A
BBC. Telefunken, Opta — Leipzig E [46, 47, 97]
Air Force LVP E A
Air Force Lorenz O A
Air Force “Telefunken” O [47]
Air Force “Telefunken” V A
Air Force “Telefunken” F [15, 46,47]
135
Name Object type Characteristic of the projectile silt

“Kohlberg" T Radio control receiver with ultra-short-wave frequency modulation to the Greifswald transmitter "
Compass" T Part of the Clapper sensor for control in the
Corfu polar coordinate system ok Target direction finding receiver or target output
Corfu V VTs Instrument flight to a centimeter-range radar station (modification “Mach R”).
“Cottbus C” with an infrared homing device similar to “Hamburg”, but with a thermocouple
“Cottbus Z” with the same, but with a bolt
“Crane” Transmitter to the system “ Kogge ”, ending tion constructive option
"Kuglokke" AB Passive electrostatic remote detonator
"Kulmbach" ok radar survey to Fight station "egerland
Kind of Armed Forces of Ken developing ala pharma Condition Sources of Staru
Air Force About
Air Force Telefunken
Air Force Blaupunk Air Force E [1, 45]
Blaupunk Air Force E [49]
Air Force Classen V [45.1 ]
Air Force “Zeiss” V [45.1]
Air Force “Telefunken” About [46]
Air Force? ? [46]
Air Force ,, Telefunken "F [15]
•? Kuno”
, Lerche ”
‟ Licht ”
‟ Lichtauto
mat ”
‟ Lince ”
‟ Luke ”
‟ Madrid ”
‟ Mangenm-
Rize ”
Modulator for‟ Kogge ” Telecontrol
system for marine torpedo by wired communication line; guidance was made on the target's acoustic bearing
Semi-active high-frequency target homing system (cf. Moritz)
Passive optical homing device with iconoscope
Passive homing device that reacts to light or infrared radiation
Passive acoustic homing device for anti-aircraft missiles
' Infrared homing device similar to the Hamburg device A
radar installation for determining the coordinates of a target in space, designed for Alsace and Brabant ”
Air Force‟ Telefunken ”V A
Navy Torpedo Commission, Atlas V [46]
Siemens - RPF V [45, 49, 51]
Air Force Golnov (Dr. Rayabauske) V [48]
Navy AEG, GEMA O [48]
Air Force RPP V [ 48]
Air Force "Cap-Win The V [48]
BBC "Telefunken" About [47]
The name Rhode object projectile characteristic or set
Marabu AV Remote fuse, based on the FuG-lOl
Marbach principle ok Radar instrument for measuring centimeter-range target coordinates for the Egerland system (in the Hansa installation)

Marburg T Radio remote control receiver, similar to the Strasbourg receiver ", but with continuous phase switched
" Max "with the high-frequency device homing cm range
" Max-a "Active device with continuous radiation of high-frequency oscillations
" Max P "a passive device for entering the radar station san imetrovogo range ( "Mad-up")
"Mayze" AV acoustic remote fuse for X-4
"Mistel" In Samoletnaya pair "Hukepak"
Type vooru- conjugated By forces developed or firm The state of the sources
Siemens Air Force F [46, 47]
Telefunken Air Force F [15] Staru Air Force
V A
Blaupunk Air Force [48, 49]
- - O -
- - F -
Rurshtal Air Force, Donag F A
Air Force - E [12]
"Moria"
"MO-12"
"Nazhori"
"Natter"
"Naxos"
"Naxos Z"
"Nultsir-
kel"
NY
NYK
semiactive high homing device, responsive to a wideband target radiation spectrum irradiated terrestrial transmitter
In See. " Argus-Project ”
T Ground installation, creating a
guide plane for guiding the A-4 rocket; the operating frequency of the installation is 500 MHz
In manned reactive
consumer of automatic control during vertical takeoff
OK receiver eavesdropping detection type and radar direction finding centimeter
VTS Device for flight station "Rotterdam" et al.
T Installation for creating HA
directs to control the missile plane A-4
system telecontrol marine torpedo from the plane on a long-wave radio line
Telecontrol
system for a sea torpedo via a wireline from the shore or from the aircraft of the
Air Force RPF V [48, 50, 51]
Telefunken SA V [P]
Air Force Bakham O [9, 10, 105, 106]
Air Force „Telefunke n ”E [1, 15, 45]
Air Force Telefunken? [45]
CA?? [46]
Navy,
Air Force TVA-Siemens O A
Navy TU A O [46]
Name Object type Characteristic of an
Oster Haze projectile or installation T Terrestrial transmitter for the Hawaii
Papagai system T A-4 rocket receiver for guidance using the Papagayt directing plane
Similar to Papagay receiver ”With steel tubes

‟ Papagist Z ”T Airborne receiver of the A-4 rocket, guided along the directing plane created by the Nulzirkel installation
‟ Pinsher ”AB A proximity fuse similar to the‟ Cockatoo ”fuse, but operating at longer wavelengths
‟ Pinzel ”of the UZ Television pointing device, similar to the ‟Tonne” device ‟ Pistole.” AB Optical remote fuse
‟Pol” T Attachment to the ‟Clapper” command sensor for control in the polar coordinate system
Kind of armed village KEM- designed or company Status Sources of
Telefunken SA? [46]
Telefunken SA E [46]
Telefunken SA? [46]
Telefunken SA? [46]
air force? ? [46]
air force? ? [46]
Air AEG O [46]
Air "Telefunken" V A
"Potsdam"
"Radish"
"Reynbote"
"Reinhold"
"Rheinland" "Rheinland oV"
"Rheinland S"
"Reyntohter"
R-1
R-3
T transmission system
Te- I command for missile A-4

C Passive homing device
for installation in the Fritz-X falling bomb to hit ground-based radio transmitting stations.
Four-stage long-range missile of the ground-to-ground class with powder rocket engines (uncontrolled)
T + OK Direction finding and coordinates coordinates of anti-aircraft missiles with control point
T + OK Anti-aircraft missile control system; common name
T + OK Terrestrial installation for optical monitoring of the
T + OK Rhineland anti-aircraft missile with a system that ensures the transition to the planning of vertically launched Wasserfall rockets
Two-stage remote-controlled anti-aircraft missile Reintokhter
som 1750 kg
Same as 976 kg
with starting weight
? ? [46]
Air Force RPF V [48]
CA RhB E [9, 11]
Air Force Telefunken 0 [47]
Air Force Telefunken V [U, 46.47, 114]
Air Force Telefunken 0 [46, 47]
Air Force Telefunken V [46, 47]
Air Force RhB 0 [9, 10, 47, 95]
- - - [9]
- - - [9]
Name Object type Characteristic of the projectile or installation
R-4 M r Uncontrolled air-to-air missile ”
RT-101 s Optical homing device for the falling bombs
“ Rize ”ok Radar station with a 7-meter reflector; Improved version of the Würzburg station
Rüse (Rück-Zänder) approx. Bearing transmitter on board the
Shemterterling anti-aircraft missiles . Remote-controlled anti-aircraft missile, same as Hs-117
“Schnabel” with
“Shus-Makh” anti-aircraft missile homing devices . Option of a high-frequency homing device for controlling the weapons of the night fighter
“Schwan-Land” ok Radio beacon discharged in the designated place, whose signals can be received by the
SD-1400 X high-frequency target exit device c Same as ,, Fritz-X ”
Type of Ken's armed forces developed or company State Sources
Air Force BhB E [11, 25]
Air Force DVL O [29]
Air Force Telefunken E [15]
Air Force Telefunken ”F [47]
Air Force HFW F [9-11, 47, 95]
Air Force? ? [46]
Blaupunk Air Force FFO-Goethe-V [49]
Air Force Vent? [45]
Air Force DVL, RhB E [25, 97]
“Seedorf”
“Ski Bauten”
“Sönlein”
"Shprotte"
"St. Mo-

matrices"
"Strasbourg"
"Strasbourg H"
"Taco"
"Typhoon"
"Tonne '
CA
T
CA
CA
T
t
m-p t
CA
television receiving apparatus for" Tonne "
Startovaya'Platforma to run Fi -103
On-board installation for remote-controlled anti-aircraft missiles (included in the Rheinland system)
Television head for anti-aircraft missiles
Target receiver in the Licht system
Radio control receiver in VHF (for working with the Kel transmitter)
Strasbourg receiver with an additional device for receiving remote explosion commands

Telecontrol system for boats with bearing planes from a high-speed boat or from the ground Uncontrolled volley anti-aircraft missile
Television camera for targeting the
Air Force Fernsee F [27, 98]
Air Force Tolt [P]
Air Force Telefunken O [46, 47]
Air Force Fernsee RPF, Telefunken O [48, 49]
Air Force RPF V [50]
Air Force Staru E [15, 46, 47, 97]
Air Force Staru F A
Navy? ? [46]
? HVP E [9]
Fernsee Air Force F [46, 48, 27, 98, 99]
Name Object type Characteristic of the projectile or installation Type of armed forces Developed by or firm Status Sources
“Tonne A” - Option for installation on “Hs-293” and other Fernsee Air Force F [46, 48]
“Tonné R” - Option for installation on the B-4 tank of the Blaupunkt SA [48]
Trichter AB High-frequency proximity fuse was used in conjunction with the Max A homing device Blaupunkt V [49]
V-1 V Same as Fi-SW; combat use since June 12, 1944. Fizeler-LVP Air Force E [8, 11.25]
V-2 P Same as A-4; combat use began on September 8, 1944 CA HVP E [8, 11]
V-3 P Name of the Schmetter-Ling projectile for propaganda purposes (?) F [95]
V / H system T A system creating a radio beam for control in the vertical and horizontal planes of the Air Force? V And
"The in memory "t The common name on the radio control system _ Air Force A
“Wasserfall” r Television-controlled supersonic anti-aircraft missile with vertical launch SA, Air Force HVP O [9, 10, 11, 25, 47]
10 Telecontrol
“
Wasserlinse”

“Wassermann-
Halbe”
“Windhund”
“Wünsdorf”
X-Halbe
X. ..
X-1
X-2, X-3 X-4
X-5, X-6
ВЦ
Further modification of the “Lince” device
Same as the “Licht” system
Passive high-frequency homing device for flying to an American airborne radar station
( AB) Infrared device for automatic activation of airborne weapons when flying over tanks and locomotives
(VC) A device for boarding an aircraft having one or another radar installation on board
B Wing-wings of various
designs
B Same as ,, Fritz-X ”and SD
1400-X
B Further modifications,“ X-1 ”
R missile of
"air -to-air." projectile weight 60 kg, is controlled by a wired communication
RELATED X-1, but a much larger size (armor-piercing bomb weighing 2500kg)
Navy AEG, GEMA V [48]
air "Siemens" V [45]
RPF Air Force? [48]
ELAC Air Force? [45.1]
Siemens Air Force? [45]
DVL Air Force - -
DVL-RhB Air Force E [9, 10, 25]
DVL Air Force? [9, 30]
Rurshtal Air Force ”F [9, 10, 11, 25, 95]
Air Force DVL? [9]
Name Object type Projectile description Installation

X-7 P Small-caliber anti-tank missile guided by the
Zeringen communication line M Remote-controlled ship used as a target of the
Tsaun König C Passive acoustic homing device for Tsossen torpedoes
(AB) Infrared device for automatic firing from onboard weapons (for Me-163)
Type of Armed Forces Who is developed or the company State Sources of
SA? About [9, 10, 25]
Navy (Siemens) (B) -
Navy Torpedo Commission “Atlas” E [14]
AEG Air Force? [45.1]
Table 10
3.32. GERMAN REMOTE CONTROL (AND RELATED TO HIM) WEAPONS
Start
Start place Start type Start nature start type start device Target type Type of controlled object Name Engine or mover Type of control Remote control line Control method Status
^ V CO 1 O) J tQ <1 ° I Ground Earth Subversive tank Submarine charge carrier “Goliath” Caterpillars Caterpillars Tele- control Tele- control Wired Radio Separate commands Same E F
Earth>, <C Free vertical; launcher Launch launcher \ On- / terrestrial (flat; sparing; Tanks Aircraft shell; Long-range missile; Small-caliber rocket launcher Fi-103— Fau-1 A-4 - Fau-2 X-7 “Argus-Ror” rocket engine Porokhovoy RD Standalone Standalone + telecontrol Telecontrol Radio Wired along three axes Along three axes, along the beam and azimuth is flat. Continuous E E O
Launcher Launcher Aircraft Aircraft Anti-aircraft missile Anti-aircraft missile “Voorilie” “Reintohtehr” Porokhovoy RD Porokhov. two-step stand-alone Tele-control Radio PS to two axes O
Start Type of target Type of controlled object Name
Start place Type of start Type of start and type of starting device
to «c >> <c Launcher Launcher Free vertical Launcher, vertical Self - years Airplanes Airplanes Anti-aircraft missile Anti-aircraft missile Anti-aircraft missile Jet fighter “Enzian” “Schmetterling” “Wasserfall” “Nutter”
Beach 1 Ot- Pipe Nad-Bystro- “Tasso”,
or 1 ride water Khodnev "Flit-
Ships <boat CER"
/ Pouce Sub- torpedo NYK
V Water
Substituting T Start Rube Sub- torpedo "Lerche"
aqueous water
Nye
boat
Start Pipe Sub- torpedo "Tsaun-
aqueous Koenig"
engine or propeller type Lnnnya teleup- control method for controlling a systematic way of Co- stoya-
LRE Tele Management Radio \ O
LRE Tele-control Radio> Continuous F
LRE Tele-Radio J O LRE
control
Automatic
(only all old! Time ha) O
Screw Tele-control Radio Continuous?
Screw Tele- Pro- Continuous-
control of water About
Screw Tele- Pro- Guidance

control of water by sound emissions V
Screw Self- Pro- Acoustic-
guidance water homing E
148
Self-<; years
Land or sea Falling bomb Falling bomb FB-I000 “Fritz-X”
Area Planning bomb GB-200
Area Planning bomb BV-246
Start <Free Land or sea / Planning 1 bomb I glide bombs Hs-293 Hs-295
Marine glide bombs with a device for the water input Hs-294
Sea Surface torpedo BV-143
Without
dviga-
of Tell
Without
dviga-
of Tell
Without
dviga-
of Tell
Without
dviga-
of Tell
LRE
LRE
LRE
LRE
Tele-control Radio Continuous V Tele- control Radio or wire
Continuous E
Autonomous - Two-axis V
Autonomous - Three-axis
V
Tele- control Tele- control Radio or wire> Continuous> E V Tele - control 1 O
Autonomous (+ telecontrol) Radio In azimuth, along three (two) axes
149
Start
Place of launch Type of launch Type of launch I type of launch device Gender Type of controlled object Name
Marine Torpedo NY
From 1 year j Ground, sea or Air Plane as a charge carrier “Gukepack”, “Mistel"
<Start <N a- the directing aircraft Jet projectile of a class "air-air" X-4
Guide Aircraft Same Hs-298
Engine or propulsion Type of control Telecontrol line Control method State
Screw Tele-control Radio Continuous O
Screw Tele-control Radio Continuous E
LRE Tele-control Wired Continuous F
Powder Tele-control Radio Continuous O
Table 11
3.33. GERMAN TELECOMMUNICATION DEVICES
Method Name Carrier frequency Modulation type Control object Co-
Telecommunication line of the transmitter of the command receiver for transmitting
stand-alone FuKS-8 FuKS-8 VHF COMBI-ET_ | 11 nation og * “FM V-4 ( tank) F
teams "Kael" "Strasbourg" VHF BM-A-4 LF AM 1 Bombs and anti-aircraft E
“Mar- VHF VM-Ch-2 LF AM 1 missiles V
Burg”

‟Kol- VM-A-4 LF AM Hs-298,
Radio mar‟ VHF Hs-117 F
<‟Greifswald” ‟Kolberg” VM -A-4 LF FM - About
Continuous ″Kai” 1 ‟Kog- 1 gr″ ‟Brig” Decimeter) VM-Ch-2 LF AM
jerk ‟Freewaves \ Any F
‟ Crane ″Generate” Dec waves! O
NY 100 kHz? AM Torpedoes O
Along the ‟Hawaii” beam ‟Papagai VHF 50 Hz –2LF A-4 E
Single-wire Continuous (Art.)‟ ГК?? _ Torpedoes O

Sep. Goliath Constant. current Impulses -
Wedge Heel E (. „Düssel- (X-4) Direct current BM-A- ± - X-4 F
Two-wire / water) Continuous (dorf" <"Duren" • "Dortmund" "Detmold ″Direct current BM-A- + -‶ Fritz-X ″F
(‶ Duyburg ″Low frequency VM-Ch-2 LF - Hs-293 E
Note: VM — time modulation; A — amplitude manipulation; H — frequency manipulation ,
AM - amplitude modulation; FM - frequency modulation; LF - low frequency.
Table 12
3.34 GERMAN INSTRUMENTS stating the purpose and homing.
energy Form method name The wavelength range Rod goals Assignment Technical features of the Co- stoya-
Flens- burg "1.35-1.75 m airborne radar ASV and transmitter noise Istrebi- Teli (night) -?
Passive “Corfu” 8-12 cm Airborne radar station “Rotterdam” Fighters (night) Heterodyne receiver with horn antenna E
High-frequency electro <magnetic vibrations of the HF Semi-active HF “Corfu V” “Naxos Z” “St. Naxos Z” Moritz ″3.1 cm 2.4-11 cm Decimeter Airborne radar station‶ Maddo ″Airborne radar station Fighter aircraft (night) Fighter aircraft (night) Fighter aircraft (night) Modification‶ Max ″Detector receiver with a dielectric antenna Licht system E? V
Radishen HF-VHF N ground transmitter Drop bombs Frame + dipole V
Passive C * “Max R” 3.1 cm Airborne radar station “Maddo” Anti-aircraft missiles Klystron receiver dielectric antenna F
“Windhund” Centimeter Airborne radar Anti-aircraft missiles -?
Active “Max A” 3.9 cm
High-frequency electro <magnetic vibrations Active “Duckel” Decimetric
Semi-active With “Moritz” Decimetric
“Hamburg” 1–3.5 μ
Infrared radiation 1 Passive “Madrid” “Armies” 1-3.5 microns 1-3-3 microns
Aerial
Anti
- aircraft missiles
Aerial
Anti
- aircraft missiles
Aerial
Anti
- aircraft missiles
Aerial (and marine)
Anti-aircraft missiles (and dropped objects)
Aerial
Air
Anti
-
aircraft
missiles Anti - aircraft missiles
Magnetron transmitter of continuous generation O
Radar transmitter of pulsed radiation?
“Licht” system V
Photocell, reflector, disk with a special cutout O
The same V
Photocell V
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Energy form Method Name Wave range Range of purpose Purpose Technical features State Infrared <radiation Passive (“Rhine-metal”) „ Emden I "1-3.5 MK 1-3.5 microns Aerial Air (and sea) anti-aircraft missiles Anti-aircraft missiles (and dropped objects) Photocell, two modulating disks Photocell, lens, disk providing coordinates in the polar system V O

„ Emden II ”1-3.5 microns Aerial Anti-aircraft missiles Photocell, disk for receiving dinatv Cartesian V

Infra-red radiation Passive-1 C \ “Cottbus C” “Cottbus Z” Infra-red Infra-red Thermo 'element Bolometer VV

Infrared or visible radiation

Visible

radiation

Passive C

Passive CA

(Wasser-Lens) Infrared or light

‟Emden- Tad ”0.4-0.8 microns

RT 101 0.4-0.8 microns

‟ Licht-machine G ”0.4-0.8 microns

‟ Tonne A ”(decimeter)

‟ Tonne R ”VHF

‟ Shprotte ”<(Decimeter)

FB-50

‟ Adler ”

Marine High-speed boats Photocell, modulating disk O

Modulated light source Marine Land and Sea (Method) Falling bombs Drop objects Photocell, eccentric disk Photocell, altitude regulator Iconoscope V O V

Ground and sea Hs-293 Superiko, 441 line F

Ground Tanks (B-4) Superiko, 441 string

Air Anti-aircraft missiles Superiko, oblique rasters O

Air Anti-aircraft missiles Nip-kov disk, 50 lines V

Land and sea Discharged objects Iconoscope, spiral sweep V

Energy form Method Name Wave range Target type Designation Technical features Condition

1 Sound 1 vibrations <in the air I Passive C Passive C “Dog” “Lux” 100-200 Hz low-frequency Air Aerial X-4 Anti-aircraft missiles 2 microphones, rotating flywheel 4 microphones, 1 amplifier O V

1 Active ELAC Low Frequency Aerial Anti-aircraft missiles 8 microphones, 4 amplifiers U

Sound waves in water Passive S “Caunkönig” LF Water objects Torpedoes 2 magneto-striction receivers E

Sound waves <in air Passive UC “Lerche” 35 kHz Water objects T orpedos Office by wire from a submarine?

Active “Gayer” Water bodies Torpedoes - V

Note: CC - target exit device; UTs - target guidance device or target guidance system; C - homing device; HF - short waves, VHF - ultrashort waves, LF - low frequency region.

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3.35. GERMAN AUTOMATIC EXPLOSIVES

Table 13

Energy form Method Name Technical features Condition

Electrostatic Passive (remote “Kuglokke” Aircraft electric charge?

Polar)

Electrostatic Active (approx. (AEG) Change in capacitance (conductor in the field) electric field) O

Magnetostatic Active (?) “Isagrim” Change inductance (yellow

field in a magnetic field)?
Magitostatic Active (remote - “Magnet- Same E

field) minen
Active ( approx. “Cockatoo” Doppler effect (decimetre
) wavelength) F
Active (?) “Pinscher” Doppler effect (meter waves
) d
High-frequency Active (approx. “Trichter” Doppler effect (centimeter
electromagnetic • live) waves, disk diagram,
oscillations combined with “Max A”) V
Active (?) FuG-380 Synchronous detection, feedback
via antenna?
Active (remote “Marabu” Frequency change according to sawtooth
law) similar to FuG-101 F
altimeter Visible radiation Active (remote st) „Pistol" Reflection of modulated light O

Sound vibrations Passive (remote “Maye” Microphone in the X-4 F head
in the air)
Table 14
00
3.4. AMERICAN AND ENGLISH SAMPLES OF CONTROLLED WEAPONS AND EQUIPMENT FOR THEM
Name Country Characteristics of the projectile or installation Literature
"Azon" A Radio-controlled remote control bomb from a uterine aircraft. Control only with respect to the vertical axis [28]
“Antidiver” A Radar installation SCR-584 for combating aircraft with V-1 projectiles [28]
“Aerobi” A High-altitude missile, further modification of Vines - high-altitude probe [9, 10]
“Bumper "A Two-stage high-altitude missile consisting of A-4 as the first and VAK-Korporal as the second stage
“Block” A General designation for television equipment of remote-controlled objects [28]
“Boyler” A Remote-controlled flying object [28]
“Bomark” A Remote-controlled supersonic anti-aircraft missile (Boeing) [U5]
“Backfire” B Studies conducted by the British after the war, on Captured Fau-type remote-controlled weapons [113
“Bet” A Planning bomb. Guidance by radio beam or homing by the active method (IUD) [9, 95, 115
“VAK-Korporal” A High-altitude rocket weighing 300 kg, payload 11 kg, can also be used with A-4 as the first stage (see “Bumper” ") [9, 10]
“ Viking ”A High-altitude missile weighing 5 tft, engine weight 9 t, can be used as a long-range missile (“ Glen Martin ”) [9, 10, 115
Vines A High-altitude rocket with a payload of 70 kg (measuring equipment) [9]
Gargoyle A Armor-piercing planning bomb weighing 1,000 pounds with a jet engine. Radio or homing [9, 28, 95]
“Hlomb” A Planning bomb weighing 4,000 pounds with a jet engine and a television indication of the target (towed to the target by a fighter) [28.95 J
“Gorgon” L Missile projectile class “air—” air ”with radio remote control or with a homing device [IUD] [9, 28, 95 J
“ Greenbottle ”A Target device, which is a radar of a submarine [28]
“ Dodar ”A Device for determining the direction to the target and range to the target using ultrasound (similar to “Sodar”) [28]
“Dre gon "A See" Rock "
,, Coever 774 ”A Post-war high-altitude missile, similar to A-4 [9]

‟ Korporal E ″A Long-range remote-controlled missile [11 G,]
‟ Crossbow ″B Allied operation to destroy ground installations for launching V-type projectiles [П]
„ Lark ″A‟ Fitchild ″anti-aircraft missile with homing device [25, 115]
‟ Little Joe ″A See KAN [9, 28]
‟ Moon ″A Modification of the Fau-1 for underwater launch (Navy) [N5]
" Madame -X ″A High-frequency proximity fuse [28]
‟ Mite Mouse ″A Uncontrolled missile, launch from an airplane, used by electric prism sight [25, 115]
“Matador” A Martin B-61. Remote-controlled long-range projectile [25, 115]
“Muff” A Remote-controlled object [28]
“Mot” A Bomb with a homing device for reaching the transmitter of a radar station detecting the enemy [28]
Name Country Characteristics of the projectile or installation Literature
“Nike” A Anti-aircraft missile with homing device (‟Douglas-Western Electric”) [15. 25, 115]
“Neptune” A Option that preceded the Viking rocket [9]
“Active” A Remote-controlled rocket weighing 570 kg [9]
“Pelican” - Remote-controlled projectile [28]
“Razon” A Like Azon, but control is carried out by two coordinates of the Fritz-X rectangular control system [28]
Regulus A A projectile; start can be made from the coast, ship or submarine (Naval Forces — Chance Vout) [П5]
“Rex” A Pulse system for remote control [28]
“Rock” A Remote-controlled object with a television target indication [28]
“Snowflake” A Rocket for lifting to the height of the foil in order to interfere with the operation of the radar station (‟Window”, ‟Dupel”) [28]
“Sodar” A Sound Radar - sound locator (Bell laboratory) [28]
“Sonar” A ‟Sound Navigation and Range”, sound sonar. The general designation for instruments designed to determine the position of an object under water by sound vibrations [28, 103]
“Sofar” A ‟Sound Finding and Raging” - sound locator (IUD) [28]
“Spanel” A Radio-controlled missile. Shooting from a fighter aircraft [28]
“Studio” A See ‟Fairy Rocket” [25]
“Secret Tim” A Rocket to launch ‟Jabo” (Navy) [115]
"Taymet" A 2000 kg remote-controlled missile [9]

Terrier A Converted remote-control anti-aircraft missile [25, 115]
11
Tee A remote control Interference transmitter mounted on board a ship against telecontrolled objects [28]
Wieri Willie A System for using aircraft that have exhausted their life as a remote-controlled weapon for example, a B-17 bomber (cf. Gukepak) [28, 115]
A Remote-controlled rocket similar to Gorgon [9]
Firebird A Rye air-to-air missile with a semi-active high-frequency device homing [25, 115]
"Firebaugh Airport" Ryan A Q-2 Bethe ipazhny plane used as the anti-aircraft target [115]
"Felix" A bomb weight of 1000 or 2000 pounds with an infrared homing device [28]
“Fany” A Attachment to the onboard aircraft receiver to reach the target, which is an interference transmitter or a radar station [28]
Fairy Rocket B Remote-controlled anti-aircraft missile (similar to the Shmetter-Ling missile) [9]
Hybridrobom A Torpedo, discharged from an airplane Movement under water by means of a jet powder engine [9]
“Edward” B Radio-controlled remote control tank [28]
BRLG A High-frequency remote fuse for detonating bombs near the ground The fuse is based on the Doppler effect [28 J
BRTG A Explosion proximity sensor providing an explosion when flying at a minimum distance from the target [28]
ED-1 A Echo Doppler indicator [28]
GARF A Terrestrial fuse similar to BRLG [28]
GB A Planning bomb [28]
GMCM A Device for creating obstacles that impede the use of
remotely controlled objects [28]
Name Country Characteristics of the projectile or installation References
JB-1A A Projectile aircraft weighing 3,000 kg similar to V-1 (launch by catapults) [95]
KAN A Remote-controlled anti-aircraft missile with a proximity fuse [9]
LBD A See “Gargoyl” [9]
MABS A Magnetic remote fuse [28]
MX-570 A Missile projectile, beam guidance (NAKA) [9]
MX-904 A Planning bomb (Hughes) [25]
RV-4U A See “Gorgon” [9]
PDB A Jet bomb Element [28]
PF A Remote fuse or proximity fuse [28]
Radio-controlled RCM A Mina [28]
RHB A Bomb designed to destroy ships irradiated by a radar transmitter (semi-active homing method) [28]
RRLG A Remote fuse similar to BRLG but designed for rockets [28]
BRP A proximity fuse, operating on the principle of reflection by the target of high-frequency oscillations [28]
6RB B A bomb with an active homing system at high frequency [28]
VE 24/43 B Autonomous-controlled Vickers-Armstrong supersonic missile [9]
Note. Column 2 indicates the country to which this sample or name refers: A - USA; B - England.
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3.4. REVIEW OF THE ENGLISH AND AMERICAN SAMPLES OF THE TELEADOUS WEAPON AND CONTROL INSTRUMENTS Tab
. 14 contains the names of some American and English models of guided weapons and remote control devices. Column 4 indicates the source in accordance with the list of references placed at the end of the book.

# 3.5. SOME EXAMPLES OF SAMPLES OF THE GERMAN REMOTE WEAPONS OF THE PERIOD OF THE SECOND WORLD WAR

According to the review given in section 3.3, we now turn to the description of the most important telecontrol devices. At first, it is advisable to consider individual devices and installations (3.51), so that in a subsequent consideration of the systems as a whole (3.52), one could refer to the former. The order of presentation of this section corresponds to the order of arrangement of the material in table. 11-13.

## 3.51. Separate devices and installations

### 3.511. Telecontrol devices (cf. 3.33, table. 11);

#### 3.511.1. Radio control systems (2.331.11);

3.511.11. Radio control system FKL-8. This system was designed to transmit multiple individual commands (2.311.21 and 2.612) and was designed and manufactured by Blaupunkt-Werke specially for telecontrol of tracked objects (“V-4”, see 3.526.12). The development of the system was based on preliminary research work. Here, the experience of controlling a Goliath platform with a wireline (3.511.21, 3.526.11) was also used.

The FKL-8 system basically worked according to the scheme shown in Fig. 9 and 12. Schematic diagrams of the receiver and transmitter are shown in Fig. 41 and 42.

The principle of operation of the system [104] is as follows. The sensor for 10 possible commands (Ko G-2, Fig. 43) contains 10 pairs of contacts, 2 contacts for each command, which, in a combination of two, include Pi ... Pb relays (Fig. 41). At the moment of closing the contacts Pi ... pb, two sounds are simultaneously transmitted to the transmitter: 11 *

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KG - ultra-high frequency crystal oscillator; GPC - intermediate-frequency generator; Cm - mixer; FM - frequency modulator (L - lamp) 1; Rl is an oscillating relay.

new frequencies from D. . . / 5 (low-frequency generator, assembled on three lamps EDD-11). Simultaneously with the issuance of the command, the transmitter lock was released (via the contact pi ... p6). The modulating frequencies were connected to the command relays by means of an encryption key having four positions. Each position of the encryption key corresponded to a specific connection of low-frequency generators to the command relay. Due to the fact that each command is formed from two frequencies and it is possible to change the frequencies for each command using an encryption key, in combination with the applied frequency modulation, sufficient security of the system from false switching under the influence of random or organized interference is achieved. A special explosion command can be immediately issued via the relay Pb,

1 Lamp with variable reactance in inductive mode. - Note perev.

relay Pk. Turning on relay P6 causes the contacts p6 to be closed and the contact p7 to change, which ensures periodic connection of two low-frequency generators to the modulator input (the frequencies are determined by the position of the encryption key).
Frequency modulation occurs by means of a lamp with a variable reactance (EF-12 in inductive switching) in the intermediate frequency generator of the GPC. Intermediate frequency / 0 mixed
'Y w
N> 1
VHF
cm2
mv
HRE
I?
HF part
* -
Tr
Dm
\ LF
KSU
RFU
See,
GPC
V
ft— -
! ic
Fig. 42. Schematic diagram of the receiver installation of radio control FuKE8.
VChU - high frequency amplifier; VHF - high frequency limiter; KSU - ultra-high frequency crystal oscillator; GPC - intermediate frequency generator; Smg - 1st mixer; Cm9 - 2nd mixer; UPCH - intermediate frequency amplifier; HRE - Intermediate Frequency Limiter; Dm - demodulator (DSM - discriminator); ULF - low frequency amplifier .

with ultrahigh frequency fQ of the KSU crystal oscillator (ESN-11). The resulting frequency-modulated ultra-high frequency fs is fed through an intermediate stage (EP-14) to the push-pull output stage (two LV-1 lamps) and is emitted via a 2-meter rod antenna.
The source of electrical energy is a 12 volt battery. The transmitter is powered by an alternating current from a vibration converter operating at a frequency of 60 Hz. The vibration transducer, together with a transformer, a filter and a neon stabilizer, is located in a current power device (WR-81). The magnitude of the consumed current was 3.5-5 a.
Separate devices of the transmission unit (FuKS-8) are shown in Fig. 43.
!] —— Spn rnshs atnannna
From the battery 12 V
Fig. 43. Transmitting radio control installation to the FKL8 system of the Blaupunkt-Werke company.
The FuKE-8 receiver is a heterodyne type receiver with a double mixer (2ESN-11), a high-frequency limiter (EF-14) and a limiter

intermediate frequency (EF-12) (see Fig. 42). After demodulation of the intermediate

frequency fz— 3 MHz in the DcM discriminator (EB-11), the sound frequencies amplified by the low-frequency amplifier (EF-14) are fed to the L – C circuits tuned to the frequencies D ... /5. Sound voltage voltages D ... / 5, selected by the resonant circuits, are fed to the rectifier elements and then to the grids of the on-lamp (3EDD-11) of the Pi executive relays. . . R&. Connection of frequencies Д ... / 6 to the executive relay Pr. . . P5 is carried out using an encoder plug, which, like the encoder key of the transmitter, has 4 fixed positions. Thus, if a command is given, then the resonance circuits will select the two frequencies from which this command is formed, and this will trigger the corresponding relay P. The continuous tone commands corresponding to the given commands are formed by closing contacts rg. .. pn, which in 10 combinations of two contacts form inclusion chains. An explosion command issued from the transmitter by switching the oscillating relay Pk causes the relay P6 to periodically operate and relay P7 to periodically operate through its contacts (PB). If the contacts p6 and p7 work in phase, and this will be the case if the adopted "clock" is correct, then the capacitor C will be charged stepwise through the contact p7 and after a few connection periods it will turn on the fuse relay Pzx and Prg via an electronic lamp (^ EDD-ll ) makes the relay P6 periodically operate and through its contacts (PB) the relay P7 periodically operate. If the contacts p6 and p7 work in phase, and this will be the case if the adopted "clock" is correct, then the capacitor C will be charged stepwise through the contact p7 and after a few connection periods it will turn on the fuse relay Pzx and Prg via an electronic lamp (^ EDD-ll ) makes the relay P6 periodically operate and through its contacts (PB) the relay P7 periodically operate. If the contacts p6 and p7 work in phase, and this will be the case if the adopted "clock" is correct, then the capacitor C will be charged stepwise through the contact p7 and after a few connection periods it will turn on the fuse relay Pzx and Prg via an electronic lamp (^ EDD-ll )

The receiver has a safety device in case of failure of the commands. If in 20 sec. if no command has been received, then the temporary relay Rv gives the command "automatic stop".

The receiver current is supplied from the WR-82 device, which also has a chopper for receiving an anode voltage of 250 V. The WR-82 device is installed in the distribution block (which corresponds to the UR control device, see Fig. 9). The current strength of a 12-volt battery is 2.5-5.5 A.

The devices were manufactured in four different versions, which differed only in the frequency applied

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for transmitting commands in the VHF band. In addition, three low-frequency channels could be installed in each transmitter and receiver by changing the capacitance of the oscillatory circuit of the intermediate frequency generator.

The operating range of devices on flat terrain is about 4 km. The transmitter and receiver weighed 20 kg each, and power supplies with current weighed 18 kg each.

3.511.12. Radio control system "Kael-Strasbourg" [97]. This radio control system was developed in 1939-1942 and during the Second World War found quite widespread use at the front. Initially, it was used by the German Aviation Research Institute (DVL) to control the Fritz: X falling bomb (3.523.1) and Henschel aviation plants for the Hs-293 gliding bomb (3.523.2). Later this system began to be used also for remote control of other objects (3.525). In order to preserve secrecy, the development and manufacture of the system was carried out not in one place, but by various companies under the leadership of the Technical Directorate of General Aircraft Engineering in cooperation with the Peenemunde-West Air Force Experimental Station. In particular, the following firms were engaged in the creation of its individual elements:

Parts of the system Firm
Kel transmitter Telefunken, Berlin
Köl modulator block Leve-Opt, Leipzig Command sensor Köl 1 (for
Fritz-1) DVL, Leve-Opta, Leipzig
Command sensor Kel 3 ”(for Hen-
Hs-293 Aircraft Plants ) shelly, Schönefelde
Distribution block‟ Leve-Opt ”, Leipzig, GEA,
‟ Kel ”and special parts Felbach and other aircraft on-board installation
Strasbourg receiver‟ Stassfurter Rundfuni ”,
Stassfurg
Various equipment for the use of ‟Löwe-Opt”, Leipzig and other tortures
(The remaining parts of the reception unit are discussed below in section barely 3.523.)

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The system was intended to transmit two continuous commands independent of each other, while the size of the commands could vary. These two teams made it possible to telecontrol aircraft objects with respect to two axes (2.312.3). The transmission of commands was carried out on an ultra-short-wave radio link (2.331.11). The carrier frequency was modulated by four sound frequencies, and each command was formed by two frequencies that were periodically switched (time modulation - 2.312.24, Fig. 10, e; 19, b, 20, b and 21). In fig. 44 is a structural diagram of a telecontrol system for transmitting commands by this method. It consists of a unit located on board the aircraft (transmitting radio control unit) and a unit located in a telecontrolled object (receiving radio control unit) [97].

V-I —
BM
PA
P — transmitting unit 1-hour
Control
station (aircraft) Receiving unit PrA
U
Yar
UR
0U1
Remote-controlled object (bomb)
0%

Fig. 44. Structural diagram of the Kel – Strasbourg radio control system.

On board the aircraft (,. Control point ”) is the DC command sensor, which periodically commutes two pairs of low frequencies of the BM modulator unit, corresponding to the given command value (see Fig. 20, d). The high-frequency energy of the transmitter P, modulated by the BM unit, is emitted by the PA transmitting antenna. This energy is received by the receiving antenna. And on board a telecontrol facility. In the receiver amplification and demodulation of command frequencies occurs, which are then transmitted through filters (Fig. 19, e and 48) to the control devices of the SD, which drive the governing bodies of the OУx and OУ2 of both axes.

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g lava 3

To select one or another carrier frequency for the purpose of transmitting commands, the system had 18 working channels in the field of ultrashort waves (at first, frequencies of the order of 50 MHz were taken, and later the operating frequency region shifted somewhat towards longer waves). These frequencies were created by the S-203 transmitter with quartz stabilization. Replaceable quartz worked at frequencies two times lower than the working ones. After the doubling frequency

cascade was followed by a final cascade assembled on two LS-50 lamps with an output power of about 30 watts. The output stage was modulated in amplitude on the grid with a modulation coefficient of 40% for each low-frequency channel.
The frequencies of the teams were 1 and 1.5 kHz for one pair and 8 and 12 kHz for another pair of teams. These frequencies were created in the MT-203 modulator block, which had four L-C generators on RV 12-2000 lamps; the generators were switched by means of a command sensor with a frequency of 5 or 10 Hz. Through two subsequent lamps RV 12 R-2000 command frequencies were fed to the transmitter. In reality, switching command contacts compared to the circuit diagram (Fig. 45) was somewhat different. The command contacts closed the anode resistances of the low-frequency generators in the sequence that was adopted for the formation of teams.
The transmitter and modulator unit were mounted on a frame that was suspended on shock absorbers. Their fastening on the frame was carried out using special locks, which made it possible to carry out quick installation and dismantling. This mount design was borrowed from the FuG-U on-board radio. Power was supplied from the aircraft's on-board network (voltage 24–28 V). Anode voltage (800 and 210 V) came from the V 10/5 converter.
In fig. 45 presents in a simplified form the most important components of an aircraft transmission installation, Kel - FuG-203. Of the elements presented on the structural diagram, a command sensor requires special consideration. Its purpose is to periodically close the command contacts KK \ and / C / C2 (cf. also KK in Fig.
Examples of completed and designed systems 171
19, b and 24) so that a certain position of the control knob (the operator acts on it) would correspond to two specific command values (cf.
Modulator unit Transmitter Antenna
P and page 45. Schematic diagram of the transmitting control unit via Kel radio.
Fig. 21) for telecontrolling an object relative to its two axes. Management of command contacts in the installation in question is carried out by means of a mechanical device, which is shown schematically in Fig. 2 for control relative to one axis 46 [97].
Fig. 46. Rollers for the sensors of the "Kel-G * and" Kel-Sh "teams.
N

Fig. 47. Components of team accelerations.
! - rectangular coordinates,> - polar coordinates.
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To change the value of the command, the contact device moves along the length of the rotating roller. Two types of devices were used: a rotating roller divided into two parts with contact brushes pressed against it and a mechanical contact drive with the help of a figured roller with a recess along a helical line. Depending on the type of contact device (the contact moves parallel to the axis of the roller or along the arc) and the shape of the profile of the rollers, various relationships can be obtained between the position of the control handle and the size of the command. For control in two planes, two identical rollers are installed, which rotate from one common shaft by means of a direct current motor having a speed controller and contact devices corresponding to two control coordinates. The Kel 1 command sensor (for the Fritz-X bomb, the rotation speed of the rollers was 300 rpm) issued commands in a rectangular coordinate system (left – right, up – down). The Kel III command sensor (for the Hs-293 bomb, the rotation speed of the rollers was 600 rpm) issued commands in the polar coordinate system (tilt to the left - tilt to the right, to the target - from the target). (See Fig. 47 [97], as well as section 1.412, Table 3.)
In later versions, an electric pulse generator was provided (the so-called “kippknip-pel” - multivibrator, cf. Fig. 24, c). In this embodiment, the control device had only two potentiometers. This design greatly simplified operation, as the number of moving parts was sharply reduced. All other parts of the installation (modulator unit, transmitter, antenna tuner) during the flight did not require maintenance, and therefore access to them for crew members was closed. The aircraft antenna was a V-shaped wire dipole; it was stretched between the stabilizer and two entries located diametrically opposite to each other in the fuselage.
The radio remote control installation included, in addition to the main units shown in Fig. 45, necessary for actual remote control, source.
Examples of completed and designed
power supply systems 173 , as well as a large number of additional elements designed for maintenance, monitoring, and switching on. All these additional elements were necessary in order to control the launch of the receiving unit in the telecontrolled object, the preparation for the reset and the reset of the controlled object itself, as well as to establish the correct sequence of processes in time and to regulate the course of these processes. The connection between the aircraft on-board unit and the receiving unit until the moment of dropping was carried out by means of a 14-pin detachable connection (Fig. 86).
Onboard installations for various telecontrolled objects were also created:
KelG -
FuG-203 a - for dropping one Fritz-X bomb
Kel III
FuG-203 b - for dropping one Hs-293
Kel IV bomb -
FuG-203 s - for dropping either one Fritz-X bomb or one Hs-293 bomb.
FuG-203 cl and all subsequent ones - for optionally dropping from 1 to 4 Fritz-X or Hs-293 bombs.
(“Kel II” -
FuG-204- is a ground-based radio transmission installation for remote control of the miniature “Argus” MO-12 aircraft, which was used as an anti-aircraft target (3.526.34). For this installation, an MT-204 type modulator unit was designed, which low frequencies have been changed).
Such on-board systems could be installed on aircraft such as He-ll, Do-217, Fw-200, He-177 [25]. Airborne fighter aircraft installations for remote control

on air-to-air missiles had the code FuG-206 (3.524.2).
The remote control system FuG-203 with and subsequent ones had the same aircraft-based transmitting installations for dropping the Fritz- falling bomb X ”, as well as for the Hs-293 gliding bomb, and the radio control receiving installations working in conjunction with the transmitting installations had their own peculiarities and significantly differed from each other in the connection diagrams (2.312.1). Some features also existed in the corpus configuration Fitting meat, which was due to the object telecontrol device body (3.523.1 and 3.523.2).
The receiver used in both installations (FuG-230 a and FuG b) was the same. In fig. 48 shows the block diagram of the Strasbourg device (E-230) [97]. The control commands for both coordinates were separated by two low-pass bandpass filters after preliminary amplification of the low frequency. Bandpass filters passed frequency bands D, / 2 and / 3, D. After further amplification, individual frequencies D, / 2, / 3, D were distinguished by resonant circuits, and after rectification, the signals were fed to the windings of the control polarized relays Pi and P2 (telegraph relay T . rls.-64).
/ State
KSKYA
A
Filters
CZCH-G4
hA 44
Low-frequency part
Fig. 48. Block diagram of the radio control receiver “Strasbourg”
In ChU - a high-frequency amplifier; UP H - intermediate frequency amplifier; VLF - low frequency amplifier; Cm - mixer; G - generator: Dm - demodulator; AGC - automatic level control; AtP - automatic fine tuning; PN A - antenna tuning device.

Reception radio control installation as described in Section 3.523 constitute part process fitting
Sample system 175 and projected
unity to the receiver output. Contacts and p2 in Fig. 85, 86 and 91 are the contacts of the receiver relay (Fig. 48).
The first version of the Strasbourg receiver (E-30) had an RL12P-10S type switching lamp instead of a telegraph relay T at the output. After installing a relay on it, the E-230 receiver instead of lamps was assembled on only three types of lamps, namely RV12 R-2000, RV12P-2001 and RG12D2.
The operating frequency of the receiver was set using a special screw, which had channels of 18 fixed positions, respectively. The channel frequency difference was 100 kHz.
The circuits that determine the working frequency (the local oscillator frequency and the intermediate frequency) had such good temperature compensation that automatic fine tuning (discriminator - lamp with variable reactance, tuning range ± 35 kHz) in the entire working area prevented the danger of leaving the specified channel. For this, fluctuations in the operating voltage should be within tolerances
(2.74). Adjusting the local oscillator was necessary only when replacing the lamps.
Since the field strength of the receiver changed greatly during the flight of the telecontrolled object from the moment it was dropped and until it met the target (changing the range and the influence of radio wave interference), special requirements were imposed on the receiver: the receiver should have good sensitivity (about 2 μV) and at the same time be able to process a large input voltage. The regulation area of the automatic level controller was approximately 1: 105.
3.511.13. Modification of the Kel – Strasbourg system. The system described in the previous section was a serial model. From 1941 to 1944, all kinds of work was carried out to further improve this system. These works were carried out mainly by the company Stasfurter Rundfunk under the leadership of T. Sturm. In connection with the already mentioned replacement of the mechanical command sensor with a multivibrator, a method was developed that made it possible to avoid a “phase jump error”.
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The cause of this error was that when switching from one independently operating low-frequency generator to another, a voltage jump was caused, the value of which depended on the ratio of the phase values of both low-frequency voltages at the time of switching. This error is caused by the appearance on the controls (rudders) of a certain “imbalance” at K = const. As a result of this “imbalance”, the requirement for the accuracy of command reproduction when controlling the Hs-293 bomb, established by prof. Wagner. To improve the accuracy of team reproduction, the modulator block was improved, four independently working L / C generators were replaced by two low-frequency generators, operating frequencies of which were changed by ± 5% due to the parallel switching of inductances (from the command sensor via alternately unlocked diodes). Then, in the receiver, the filtering devices for separating individual frequencies D, / 2 or / 3, / 4 (see Fig. 48) were replaced by two low-frequency discriminators that ensure the operation of polarized relays (see Fig. 51). This receiver was called Marburg and was intended primarily for anti-aircraft missiles (3.525.22).
A similar output stage circuit was also provided for the Colmar receiver (E-232), which was intended for an air-to-air missile (Hs-298) (3.524.2) and anti-aircraft missile (Hs-117). He worked with synchronous detection and therefore took up significantly less space than the Strasbourg heterodyne receiver. Was its sensitivity about 5 times less than the receiver? '- 230. The Colmar receiver was produced by the Frizeke and Göpfner company in Babelsberg.
The S-205 frequency-modulated transmitter, developed by Lorenz in Berlin, was called

Greifs-Wald. The receiver designed to work with this E-235 transmitter was called "Kolberg". However, systems with frequency modulation have not been applied.
In order to ensure the successful use of telecontrolled objects in the presence of interference from the enemy, on the applicable frequency band (48.2 - 49.9 MHz)
Examples of completed and designed systems 177 of
the S-203 transmitter and E-230 receiver, it was possible to switch to spare frequency. Such transmitters and receivers, along with their antenna tuning devices (AGS-203, AGE-230, etc.), were sent to the front as spare weapon sets. Later systems FuG-203 and FuG-230 were improved in such a way that they could be used without servicing additional devices for servicing wired communication lines (FuG-207/237 or FuG-208/238, see 3.511.22 and 3.511. 23).
3.511.14. Radio systems "Kogge". While the commercially available control systems for Kel-Strasbourg radio operated on ultra-short waves (50 MHz), Telefunken, starting around 1944, began to produce a new, improved system operating on decimeter-wave waves (1100 MHz , And hell 27 cm). A series of developments called "Kogge" covered several models representing different stages of development. In these developments, great importance was attached primarily to the possibility of universal use of individual plants and devices. The installation of various systems (for example, for remote-controlled bombs and all kinds of anti-aircraft missiles) should, as far as possible, be based on the principle of placing individual units in special boxes that can easily be interconnected (compare, for example, the Rhineland system, 3.525.2). The main advantage of the transition from the region of ultrashort waves to the region of decimeter waves was that in the latter case, the on-board antenna could, on the one hand, be much smaller and, on the other hand, be installed with a certain radiation pattern (2.73). This position made it possible to install a dielectric antenna on board the telecontrolled object, while ground installations were equipped with reflective systems.

The decimeter-wave transmitter operated on small-sized lamps with disk solders and had automatic frequency adjustment. The prototype of such a transmitter was the Kai transmitter. For serial production, the “Crane” transmitter was planned.

Aircraft transmitting units were designated FuG-512, FuG-513, etc. Receiving units were designated FuG-530, FuG-531, etc. In the beginning, a Brig synchronous-reflex receiver was provided, and later a heterodyne receiver was created "Frigate". The low-frequency part of this receiver worked in the same way as the low-frequency part of the Marburg (3.511.13) and Duisburg (3.511.22) devices with frequency switching without phase jumps (cf. Fig. 51). The Kuno modulator unit, which was part of the transmitting unit, contained two low-frequency generators, which gave the following frequency groups of 6–9 kHz and 13–16 kHz.
As a command sensor, a whole series of devices was developed, which, depending on specific conditions, were adapted for certain telecontrolled objects and, accordingly, the type of object differed in control coordinate systems (1.412) and switching frequencies (2.312.24). The “Clapper” command sensor had two potentiometers with midpoints. The engines of these potentiometers were rearranged in one position or another using the control knob. The sensor for controlling in polar coordinates had a special device - the so-called “compass”, which made it possible to provide commands for lateral control within 360 °. “Clapper” command transmitter of DC voltage (-210... 0 ... +210 V) were supplied to an additional device (“Carte” or “Paul” for control in a rectangular or polar coordinate system, respectively). This additional device consisted of two sawtooth generators and two telegraph relays. The relative closure of the contacts of these relays smoothly changed due to the shift of the sawtooth voltage zero line due to the voltage supplied from the command sensor.
In addition, it was possible to submit an additional separate command (for example, an explosion command, cf. sections 2.612 and 3.514). In this case, one pair of frequencies forming the command switched to a switching frequency of 200 Hz, as a result of which a special relay connected to the output of the receiver worked.
3.511.15. Radio control system "NY". System

"NY" was developed at the German Navy Research Institute in Neubrandenburg in conjunction with the Air Force Test Station in Gotenhafen-Hexsengrun-de, as well as with the participation of the company Siemens and Halske. The system was designed for wireless control of torpedoes. The main difficulty in creating this system was due to the fact that electromagnetic waves penetrating water are extremely strongly absorbed, and the higher their frequency, the stronger the absorption.
Then they tried to conduct research on long waves (frequencies of the order of 100 kHz). However, a 100-watt transmitter, designed for use on an airplane, was therefore quite large in size. Significant losses, by the way, were also due to high voltages in the antenna.
Control was provided only around the vertical axis of the torpedo at the heading during visual observation (along the trail formed due to the release of air bubbles or coloring matter on the surface). It was possible to issue additional commands for surfacing, producing an explosion, etc. As far as the author knows, this control system in its experimental stage failed and was replaced by the NYK wire management system (3.511.25).
3.511.16. Radio beam control system. All radio control systems that we reviewed in this section worked on the principle of broadcasting control commands (2.31). Here is just one example of the practical application of the radio beam control method (2.32), with the exception of experiments on the use of blind landing beacons1. An example is the control of an A-4 long-range missile via a directing plane (3.522).

The first model of the “Hawaii I” system was equipped with a 1-ket Haze ground-based transmitter with an operating frequency of 50 MHz. This transmitter through
1. Approximately in 1940, experiments were carried out to control a gliding bomb from an airplane using a two-axis radio beam (V – H system - vertical-horizontal control), but they were soon discontinued.
12*
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special device for phase shift of the PV fed two dipoles D! and Dg, which were located in a horizontal plane at a distance of 200 m from each other (Fig. 49).
Fig. 49. An ultra-short ground terrestrial installation to create a leading plane, Hawaii G.
The installation was 12 km behind the launch site of the A-4 rocket. The radiation pattern was intermittently switched by means of an PV phase shifter with a constant frequency of 50 Hz using a synchronous motor, which simultaneously switched the transmitter modulator in such a way that a modulation frequency of 5 kHz was generated in one position and 8 kHz in the other (the method is described in sections 2.321. 5 and 2.322.2).

The motorized ground installation was called “Hawaii I” b [46]. The receiving unit for this system (Papagai (s) receiver) is described in section 3.522 (see Fig. 77).
In the Hawaii II system developed by Telefunken, it was first envisaged to use the Würzburg-Rize reflector (7 m) in conjunction with a transmitter operating in the 500 MHz frequency range (Celebes). However, when testing this system, unsatisfactory data were obtained, in particular, due to a contradiction between the requirement of sufficient accuracy and the mechanical strength of the Rize reflector (Nazhorn).
A further stage of development was the development of a facility operating at a frequency of 1500 MHz with a 4-meter reflector (L й 20 cm) [15].
3.511.2. Control systems by wire (2.332).
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3.511.21. Goliath wire management system. The system used for remote control of the Goliath platform sole (3.526.11) worked according to the method of transmitting individual commands (2.311.21) via a two-wire communication line
(2.332.12). The execution of a command was carried out due to the different order of supply of direct current pulses (2.332.21). The pulse sequence could be changed using an encryption device. The command sensor device was similar to the K0G-2 (cf. Fig. 43).
3.511.22. Wire Management System Dortmund-Duisburg. As already mentioned in Section 3.511.13, starting in 1943, for the FuG-203 — Fu-230 radio control system (Kel-Strasbourg), it was possible to switch from transmitting radio control commands to transmitting via a wired communication line in the case of significant radio interference from the enemy (2.72). The corresponding rearrangement looked something like this: instead of the FuG-203 aircraft transmission unit, the FuG-207 installation was used, which was obtained on the basis of the FuG-207 installation as a result of replacing the MT-203 modulator block (“Kel”) with a low-frequency generator (“Buzzer”) Su- 207 (Dortmund) replacing the S-203 ultra-short-wave transmitter (“Kael”) with an S-207 low-frequency amplifier and installing two coils with wires on both sides of the aircraft with their inclusion through the LGS-207 wire matching device. Instead of the FuG-230 b receiving installation (in the Hs-293 bomb), the FuG-237 installation was used. This installation differed from the FuG-230 Komp.b installation in that the E-230 ultra-short-wavelength receiver (Strasbourg) was replaced by an E-237 wire control receiver (Duisburg), as well as the fact that two coils with a wire were installed on both sides of the telecontrol object. The coils were turned on via the LGE-237 wire termination device. The block diagram of such a low-frequency transmission via two wires (2.332.12–2.332.22) is shown in Fig. fifty. This installation differed from the FuG-230 Komp.b installation in that the E-230 ultra-short-wavelength receiver (Strasbourg) was replaced by an E-237 wire control receiver (Duisburg), as well as the fact that two coils with a wire were installed on both sides of the telecontrol object. The coils were turned on via the LGE-237 wire matching device. The block diagram of such a low-frequency transmission via two wires (2.332.12–2.332.22) is shown in Fig. fifty. This installation differed from the FuG-230 Komp.b installation in that the E-230 ultra-short-wavelength receiver (Strasbourg) was replaced by an E-237 wire control receiver (Duisburg), as well as the fact that two coils with a wire were installed on both sides of the telecontrol object. The coils were turned on via the LGE-237 wire matching device. The block diagram of such a low-frequency transmission via two wires (2.332.12–2.332.22) is shown in Fig. fifty. The block diagram of such a low-frequency transmission via two wires (2.332.12–2.332.22) is shown in Fig. fifty. The block diagram of such a low-frequency transmission via two wires (2.332.12–2.332.22) is shown in Fig. fifty.
The principle of operation of the Dortmund – Duisburg system becomes clear if we consider the circuit depicted in Fig. 51. The command contact KK of the command sensor (Ge-20 &, cf. Fig. 46) connects the voltage from
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power supply to the diode Dd , alternately positive or negative. Due to this, the inductance L1 is periodically connected in parallel with the low-frequency oscillating circuit L – C, as a result of which
Fig. 50. The structural diagram of the low-frequency control system for wires "Dortmund — Duisburg."
the oscillation frequency changes synchronously to the command sensor between two constant values of D and / 2. The discriminator at the output of the E-237 receiver was tuned to the middle
frequency - and sent alternately positive
and negative pulses of the output voltage to the polarized relay P (telegraph relay). The system as a whole had two similar channels. For the Dortmund – Duisburg system, the average frequencies were 450 and 700 Hz with a deviation of + 5% (D = 422 Hz, / 2 = 473 Hz, / s = 665 Hz, / 4 = 735 Hz). The receiver allowed to significantly adjust the gain and was equipped with a limiter. This was done so that the input voltage, varying from 100 V to 100 mV, could be amplified to a voltage sufficient to operate the output relay. In the receiver and transmitter, RG-12-D2 lamps were used as switching diodes.
/ 1 + / 2
Command sensor
Switch 's receiver receiver discriminator
Fig. 51. Schematic diagram of the low-frequency switching systems “Dortmund-Duisburg” and “Marburg” (for one control plane).

The selection of these operating frequencies was determined based on the weight of the wire and its cost, on the one hand (low frequency causes a large by weight), and losses in wires - the other (high frequency causes great losses due to increased inductance wires).
The difficulty of such a by-wire control is not so much control method and constructive om performing control equipment, but in a constructive development of coils with wires for the communication lines. For coils wireline following requirements.
1. The wire should have sufficient strength to withstand significant stresses arising when pulling it out of the coil at high speed, and also have not too much ohmic resistance. At the same time, the wire should have been as thin as possible so that it could fit as much as possible on a coil of small volume.

2. Since isolated turns of wire in the coil create a large inductance, causing large losses when using sound frequencies, when winding it is necessary to ensure that the layers of wire on the coil are at least short-circuited.
From transmitter
Direction of flight
Wire to receiver.
Coil on an airplane
Connecting
cable
Coupling Cable, axial rotation - supply wire Fixing pin
The coil on the projectile
Fig. 52. The location of the coils of the control system for wires "Dortmund — Duisburg",
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For this purpose, a steel wire coated with insulating varnish (piano wire) with a diameter of about 0.3 mm was used (0.1 mm is indicated in the source [25]). The wire was stacked in turns in such a way as to form a cylindrical body, which was then glued with a special substance (to avoid kinks of the wire when it was pulled). Such a glued coil was placed in a fairing. The outer coils were left exposed to provide a short circuit between the layers due to the fit of the outer coils to the inner metal surface of the fairing.
The coils were installed in pairs on an airplane and on a dropped object in such a way that they were directly above each other before dropping (Fig. 52). The inner end of the wire of each coil with the help of a cable was led out through a well-oiled hole in the center of the fairing and was fixed by means of a cotter pin. When the telecontrolled object was dropped, the cotter pins were removed, and under the action of the oncoming air flow, the wires were pulled out of the coils (in another constructive version, the wires were unlocked when the bomb was dropped using a squib). The wire was pulled out of both coils at the same time and at the same time slowly sank down. A schematic diagram of the location of a telecontrolled object and a wired communication line after some time after the separation of the telecontrolled object from the aircraft is given in Fig. 53.
The FuG-207 / FuG-237 wire management system was designed to remotely control a gliding bomb (3.523.2). Coils on the remote-controlled object were installed on the wing consoles. The planning bomb Hs-293 had a wingspan of 2.90 m [9], and therefore the wave impedance of the two wires was about 1200 ohms. The output of the transmitter was through the LGS-207 wire matching device, and the LGE-237 wire matching device was also used at the receiver input. The wires had the following length:
12 km in a coil located on an airplane;
in a coil located on a remote-controlled object-
Examples of completed and designed systems are 185
te, - 18 km. Thus, the communication line had a total length of 30 km.
The wire control equipment was designed and manufactured by Stasfurter Rundfunk in Stasfurt. Henschel aviation plants in Schönefeld near Berlin were engaged in the design and manufacture of wireline coils.
Fig. 53. View of the wireline after dropping the Hs-293 gliding bomb.
At first, a similar control system for wires was also intended for remote control of the Fritz-X falling bomb (3.523.1). Since the flight of the Fritz-X bomb took less time than the flight of the Hs-293, accordingly, the length of the wires should have been much smaller (8 + 8 km). Studies have been conducted on the possibility of using bare wires. In this case, the coils were suspended in isolation from both the airplane body and the bomb body. However, after numerous successful studies, it turned out that the

losses in the communication line during the transmission of DC control signals are very small (2.332.21). Therefore, to control the Fritz-X falling bomb, it became possible to replace the Kael – Strasbourg radio control system with the Düren – Detmold system.
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3.511.23. The control system for wires "Duren-Detmold." This system consisted of a transmitting unit FuG-208 and a receiving unit FuG-238 and was used to transmit, with direct current (2.332.12— 2.332.21), two control commands for the falling Fritz-X bomb (forward — backward, left — right, cf. Fig. 47, a), moreover, for one control plane, a periodic switching of the current direction (+ or -) was used, for another plane, a periodic abrupt change in the current strength (strong – weak) was used. Basically, switching in this system was carried out in the same way as in the Kel – Strasbourg system with the Kel I command sensor at a speed of commutation rollers of 300 rpm and T = 0.2 sec. (cf. fig. 21 and 46). A simplified circuit diagram of the system is shown in Fig. 54.
Transmitter S-Z08
Receiver E-238
Fig. 54. Schematic diagram of the Duren-Detmold control system for wires.
The KK \ and KKg command contacts, designed to form commands respectively for two control planes, were controlled by a command sensor, which in the Duren FuG-208 aircraft installation consisted of a control handle with two perpendicularly arranged potentiometers. The voltages removed from these potentiometers acted on periodically switching relay systems, changing the relative closure of the contacts KKi and KKg (T = 0.2 sec.), which gradually changed with a smooth change in the acting voltage.

Examples of completed and designed systems are
similar to the scheme in Fig. 24.6. A constant voltage was applied to the potentiometers from a DC / DC converter.
The KKi contact system periodically changes the direction of the current in the wires, so that the Pi receiver relay oscillates synchronously with the KKi contacts. The KKg contact closes the resistance R with a frequency of 5 Hz. The receiver relay trips with a high current (KKg closed), and with a low current releases a contact (KKg open). Relay P1 is adjusted so that it reliably operates even with a “weak” current. Thus, the entire Detmold receiver (E-238) consisted of two rectifiers and two polarized relays!
One of the conditions for the smooth operation of the system was, within certain limits, the stability of the resistance of the DC circuit itself. The coils of the wireline should have an insulated wire, and there was no need to make a short circuit between the layers of wire in the coil, which was the case in the Dortmund – Duisburg system. The presence of inductive resistance of coil turns limited the length of the communication line and the switching frequency. The development of the system took place with the participation of a number of companies, namely Stasfurter Rundfunk, Telefunken and Rheinmetal-Borzig (coils for Fritz X).
3.511.24. Dusseldorf wire management system for the X-4 rocket. If both wire systems, discussed in the previous sections, were intended to replace the radio remote control system of the Hs-293 gliding bomb and the Fritz-X falling bomb (3.511.12, 3.523), then the X-4 remotely controlled projectile belongs to class “Air-to-air” (3.524.1), from the very beginning it was designed via a wire communication line. The Düsseldorf-FuG-510 transmitter of this system was basically similar to the Düren transmitter, but simpler in design. The receiving unit was the Detmold receiver, which however was implemented as part of the X-4 missile control system (see 3.524.1 and Fig. 92).
One of the significant differences of this system from the FuG-207/237 and FuG-208/238 systems was that
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coils with wires were only on the projectile, while on the carrier plane only the ends of the wires were fixed. Both coils were mounted on the consoles of the wing of the X-4 projectile (see Fig. 91 and 94) and contained 5.5 km of an insulated steel wire 0.2 mm in diameter [9]. At a applied DC voltage of about 200 V, a current of about 5 mA flowed in the communication line circuit (with a short-circuit additional resistance V, Fig. 54 and 94).
The development of the X-4 projectile control system was carried out under the guidance of Dr. M. Cramer at the Rürstahl factory in Brakved, the Düsseldorf transmitter was manufactured by the Danube Instrument Making Company (Donag) in Vienna. The same company produced the appropriate equipment and devices for tuning and testing the system.
3.511.25. NYK torpedo control system. For remote control of underwater objects, a wired communication line is of particular importance, since the possibility of using electromagnetic waves in this case is very limited (cf. 3.511.15). In view of this, following the development of the NY system, in which it was supposed to control a torpedo from an aircraft via a radio link, the NYK (K-cable) system was developed and manufactured in a small number of copies. To transmit commands, a single-wire cable was used (2.332.11), water was supposed to be the other wire. Both low-frequency alternating current (2.332.22) and direct current (2.332.21) were used. The control of the torpedo was carried out from the ship (1.312) or the coast (1.311), and only relative to the vertical axis of the torpedo. In the Lerche system (3.513. 34) such control of a torpedo by wire was envisaged to be carried out from a submarine. In this connection, one can also recall similar experiments that took place before the First

World War [3.1], as well as the design of the “airplane – buoy – torpedo” system developed by Krokki (2.333).
3.512. Devices indicating the purpose (television). Targeting method described in 2.43 (Fig. 31, 32) have a practical value for the control only aircraft and ground mobile objects on tele-

torrid target image (2.412.31) 1. Therefore, such devices were intended primarily to equip the planning bombs Hs-293 and Hs-294 (3.523.2 - 3.523.3). Preliminary studies were also carried out with anti-aircraft missiles (3.525), with self-propelled crawler vehicles (3.526.12) and with sea vessels.
3.512.1. The television system "Tonne - 3 edorf". This system, developed for the above purposes by the Fernsee company in Berlin in 1940–1944, differed from conventional systems that existed before that in that the following requirements were imposed on it [27, 98, 99]:
a) maximum compactness construction (see Fig. 55, 57, 58);
b) minimum energy consumption;
c) the use of as few lamp types as possible;
d) the complete absence of the need to configure the camera and transmitter, and, if possible, the receiver during operation;

d) the ability to respond to various degrees of illumination without additional adjustment;
f) the brightness of the image should be sufficient for observation in daylight;
g) the introduction of a wide area of regulation of the high frequency of the receiver, which is caused by a change in range during operation, as well as the regulation of the signal level with strong fluctuations caused by interference.
In addition, the system had to meet other conditions in which aircraft instruments operate
(2.74), namely, resistance to altitude and the effects of accelerations, as well as to a change in operating voltage, etc.
The required reduction in sensitivity (to avoid interference effect) achieved by the transition from normally applied in the positive modulation while synchronizing with intermittent to become now very common negative modulation (black control) with positive sinhroniziruyu-
1 Method of guidance on underwater target, emitting sound waves used in the Lerche system, see 3.513.34.
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Chapter 3
impulses, as a result of which the necessary level adjustment (e) was significantly facilitated. Later, capturing synchronization of the horizontal frequency (11,200 Hz) began to be applied, and the image scanning frequency (25 Hz) was obtained from the horizontal frequency of horizontal scanning by dividing both on the camera side and on the receiver side. This made it possible to limit the servicing of the receiver (d) by setting the tightening (± 50 Hz) by fine-tuning the master oscillator. The correct phase of the frames could be established due to short-term detuning, carried out by pressing a button. However, only the main brightness was required to be set on the receiver, since the brightness amplitude was automatically adjusted (t fb 60%) at the transmitter and receiver.
P and with. 55. Tonne television camera (without housing).
Examples of Designed and Designed Systems 191
Anode voltage was taken from a transformer sweep during horizontal flyback. It is interesting to note that the capacitance used between the inner layer and the external metallization of the picture tube, which was approximately 200 pF and was quite sufficient, was used as a charging capacitor.
3.512.11. TV camera "Tonne". The fact that the first of the above requirements in the Tonne television camera was performed in the best way, says fig. 55 [27]. The television transmitting tube with the accumulation of charges, as well as all auxiliary devices (frequency sensor, relaxation generator, video amplifier) were placed in a camera box with dimensions of 17 X 17x40 cm, so the expression “exceedingly compact” 1, used in one English report, seems quite reasonable to us . Auxiliary devices were mounted on a separate chassis, and the connection between them was carried out through plug connectors. Only two types of electron tubes were used in the circuit (PV12P-2000 and RL-12-Tj); the total number of lamps was 29. The television transmitting tube with the accumulation of charges (IS-9 superkinescope) used in the camera is shown in Fig.
The image transmitted by the collective optics (Zeiss-Biogon 1: 2.8 with F = 35 mm) to the photocathode was obtained in the format 7x7 mm2. The preliminary image system 3, covered by a focusing coil with an iron screen, created a charging image enlarged in the ratio 1: 5 on the collecting electrode. This is a charging image through a cathode beam, created-
1 Extremely compact. - Note perev.
* In one of the variants of the planning bomb Na-293, the
lens had the ability to move in the direction of the vertical
axis. The lens was

mounted using a weather vane in such a way that the optical axis of the camera coincided with the direction of flight (cf. 2.54; viewing angle from 15 to 30 ° [48]). Tests were also carried out using tilt prisms.
instead of lens shift.
8 The pre-image system includes a lens and a target for a television tube. - Note perev.
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Chapter 3
in “spur” 1, commutated with the number of lines 441 (with line jump) and frame rate of 25 .. On the “spur” there was a quotation magnet, a focusing coil and deflecting coils, as well as an auxiliary coil to compensate for trapezoidal error.
P and with. 56. Television transmitting tube with the accumulation of charges IS-9 company "Fernsee".
An anode voltage of 800 V for switching the beam was stabilized by incandescent lamps, a constant current for focusing the beam and feeding the magnetic electronic lens of the preliminary image was maintained at a predetermined level by the lamp device. So that the operation of the television camera is not affected by a change in the supply voltage, the glow current of the receiving lamp
1 The process of the iconoscope. - Note perev.
Examples of completed and engineered systems 193 were
also maintained at a predetermined value by a hydro-iron barretor. The sensitivity of the JS-9 television transmitting tube was about 40 μa / lm. The lamps worked on the input impedance of the amplifier

1 mg; the output voltage of the amplifier is about 1 in at 150 ohms. The synchronization signals were mixed on the antidinatron grid of the amplifier cascade. The camera was powered by an alternating current of a frequency of 500 Hz from the converter through a transformer. The converter itself was powered by a battery.
3.512.12. TV Broadcast. To transmit television signals, both ultrashort waves (range 80 MHz) and decimeter waves (range 400 MHz) were used.
The ultrashort-wave transmitter contained two independently controllable push-pull RS-381 pentodes with modulation on an antidinatron grid. Such a transmitter was used in a variant of a mobile ground installation (“Tonne R”) with a rod antenna. With a transmitter power of 20 watts, the range on hilly terrain reached 7 km.
For installation in aircraft (“Tonne A”), a decimeter range transmitter with a radiation power of the Yagi antenna from 10 to 20 watts was used. He worked with self-excitation on special TU-50 triodes, which were modulated by ultra-short-wavelength DU-10 diodes with a modulation depth of about 60% with a bandwidth of +2 to 3 MHz (combined modulation - load and grid voltage). Both types of lamps were designed and manufactured by Fern Zee. The range reached between objects flying at high altitude is approximately 150 km.
3.512.13. Television receiver "Seedorf". Some features of this universal receiver have already been noted above, in Fig. 57 shows its general view [27]. The compactness of its design is striking. A universal device as a “shortened” receiver (video frequency) with a screen diameter of 13 cm and a tube length of 36 cm had overall dimensions of 16x16x40 cm. If the high-frequency part of the receiver was also installed, then
13 Telecontrol
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Chapter 3
its dimensions increased to 17x22x40 cm. The receiver gave 8x9 cm image [98].
Fig. 57. Universal television receiver "Seedorf" (without housing).
The video frequency amplifier installed in the TV created at an input peak voltage of 1 at a voltage of about 30 V to control the cathode ray tube at an anode voltage of 6 kV. Anode voltage was created by a three-stage relaxation generator.
When using a television for wireless reception, either an ultra-short-wavelength or a decimeter-receiving part could be installed on board the aircraft by choice. Both of them contain a three-stage intermediate frequency amplifier (which was 8.4 MHz, bandwidth 2.5 MHz) on three pentodes LV-1 and one push-pull diode LG-1 for demodulation. The receiving part had an automatic level control that ensured normal operation.
Examples of completed and designed systems
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with fluctuations in the voltage of the input of the receiver from 100 uV ao 1 sun time constant 10ms. The sensitivity was expressed in the following values [27, 98]:
Waves
Input voltage of the receiver at 120 ohm VHF decimeter
At a useful power equal to the
noise power of 8 25 μV
The voltage in the antenna for a clear image with a modulation depth of t - 60% 30 100 μV
In addition to this universal receiver, which was installed in an airplane for use with a Tonne A camera and in a movable command unit (tank) for use with a Tonne R camera, another high-power receiver was developed by Fernsee in 1943-1945 . This receiver was even more compact and interesting in design [27, 99]. The receiver (with a video-frequency input, Fig. 58) gave an image of 11x11 cm and was placed in
Fig. 58. High-power television company Fernsee.
13 *
19G Chapter I have a

sealed cylindrical case with a diameter of 17 cm and a length of 37 cm (the height was provided at an anode voltage of 12 kV).
A special television tube was also developed (screen diameter 12 cm, length 30 cm), which was used with a beam deflection angle of up to + 35 °. In fig. 58 you can see the location of individual parts around the cathode ray tube. The individual elements of the chassis of a cylindrical shape (Fig. 59) were connected together,
Fig. 59. Separate nodes of the chassis of the television receiver.
at the same time, electrical circuits were connected using multi-pin plugs [27]. Due to the tightness of the structure, it was necessary to pay special attention to cooling. Instead of conventional cooling by radiation and airflow, the heat generated inside the device (power consumption was about 50 watts) was removed due to heat conduction. This was ensured by the fact that part of the lamps was placed in aluminum sleeves, which were inserted into the holes in thick aluminum disks in such a way that heat was transferred through the chassis to the entire body.
3.512.2. Other examples of television systems from Fernsee.
3.512.21. "Sprotte". The “Shprot-te” television head was a further modification of the “Tonne A” television camera. This head was intended for
Examples of completed and designed systems 197

the first turn for anti-aircraft missiles (3.525). The developments were carried out by the Fernsee company, the Telefunken company, and the Scientific Research Institute of Post, founded in Berlin in 1937 [48].
The small-sized television transmitting tube with the accumulation of charges, created by Fernsee, is shown in Fig. 60 [98. ]. Basically, its design corresponded to the design of the IS-9 tube (Fig. 56), however, the dimensions were much smaller.
Fig. 60. Small-sized television transmission tube with the accumulation of charges of the company Fernsee.
The camera was designed for the number of lines 200-300 at a frequency of 10-20 frames per second and had the so-called "oblique scan rasters." To implement this method, two horizontal generators were located in the camera and receiver, which operated at two different frequencies (10,000 and 10,050 Hz). A diagonal raster was formed due to beats that occurred under the action of two perpendicularly deflecting systems, while the voltage of the frame change was created by dividing the frequency [27, 98].
If several hundred units were manufactured by the Tonne units, the Sprotte system was brought only to the prototype stage. When developing the airborne receiving system for the S. Zenlain anti-aircraft missile ”, see 3.525.2), a later model of the targeting system was already taken into account.
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3.512.22. FB-50 Toward the end of the war, the need to reduce the cost of the equipment appeared, so the Fernsee firm took up the development of a television device that produced 50 lines at a frame rate of 25. The FB-50 installation, designed for the Entzian anti-aircraft missile (3.525.12), was supposed to work with a mechanical switch (Nipkova disk) at an angle of view from 7 to 12 ° [48].
3.512.23. "Adler". The development of this device was started by Opta Radio in Berlin in 1942. Later, this development was discontinued. The device "Adler" worked with electronic spiral switching.
Research works in the field of the television method for controlling flying objects (2.412.31) were carried out by various organizations, but they were carried out most intensively by the German Glider Research Institute in Ainring [33–44].
3.513. Homing devices. During World War II, a large number of homing devices were developed or were under development in Germany (cf. 3.34, table 12). But these projects were not brought to the finished samples (with the exception of the Tsaunkenig torpedo launcher, which reacts to sound vibrations in water, see 3.513.34), so there was no final opinion on the true suitability of these projects1.
The devices considered in this section were classified by type of energy consumed (2.55), while for individual samples, a classification was given according to the location of the energy source (2.56).
3.513.1. High-frequency homing devices (2.552.11).
3.513.11. "Radishkhen". The Radishan device was a passive device developed by the Postal Research Institute for installation in bombs (a special version of the Fritz-X falling bomb, see 3.523.1) for the destruction of terrestrial radio transmitting stations. His first models worked on short waves, however, in further developments
1 The data presented are mainly taken from a report [48], which was available to the author, but without corresponding illustrations.
Examples of completed and designed systems
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The use of this homing device was also envisaged against ultrashort-wave transmitters [48].
The direction finding method used in the Radiskhen device was based on the fact that the direction to the transmitter is always perpendicular to the vectors of the magnetic and electric radiation fields (2.552). To determine these vector directions, a loop antenna and a dipole were installed on the device, between which a metal oblique

washer rotated. The axis of rotation of the latter coincided with the direction of the longitudinal axis of the controlled object. Distortions of the magnetic and electric fields introduced by the oblique washer contributed to the fact that a voltage appeared at the output of the receiver connected to the antennas, the frequency of which corresponded to the speed of rotation of the washer, and the magnitude was proportional to the deviation of the longitudinal axis from the direction to the target (cf. 2.52). Of course, it was meant that this device was installed only in the facility, which itself could not create a significant distortion of the fields (the falling Fritz-X bomb had symmetry about the longitudinal axis). After rectification of the low-frequency voltage, the device gave a direct current voltage at the output, which was supplied through the switch, rotating together with the oblique washer, to devices including flow-break switches1 for the falling bomb (cf. Figs. 82–84, 92).

3.513.12. "Max". The homing device Max was developed by Blaupunkt Werke in Berlin in two versions: as a passive device Max R and as an active device Max A.

Passive homing device "Max R" was supposed to provide automatic guidance of the projectile on aircraft armed with airborne radar stations, especially the American panoramic radar "Madow". Accordingly, the length of its working wave (L) was 3.1 cm. The device worked on the principle of direction finding by an equal-signal zone in two planes (cf. Fig. 35 and 2.512.2).

1 Interceptors. - Note perse.
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A number of serious experimental work was carried out with various antenna devices; with fixed (2 pairs, see 2.512.21) and rotating antennas (2.512.22) having a parabolic reflector, with dipole or waveguide excitation, as well as with dielectric antennas. Based on these studies, the most acceptable was the option consisting of four dielectric rods (trolitulum), which were switched in pairs by a capacitive collector. In fig. 61 is a structural diagram of this device,
Fig. 61. The scheme of the homing device "Max R".
Two pairs of antennas AL, Ar2 (horizontal plane) and Al, Av2 (vertical plane), located on a convex base made of sheet iron, have a radiation pattern, which basically corresponds to the diagram in Fig. 35. For the selected rod sizes (length 170 mm - 5.5 L, base diameter
15 mm Pd -, taper 1.9) and with a solution angle of 2f5 - 20 °
2, the
half width of the radiation pattern under conditions of a power increment of about 50 was 2 Ra 30 ° [49].
High-frequency energy from 4 rods was fed to a capacitive switch, which rotated from a quick-turn.
Examples of completed and designed systems 201
with a speed of 3000 rpm, synchronously with a low-frequency switch (output). To get the output value without distortion, it was necessary to make jumps, which necessitated the use of a Maltese drive. In order to balance the high-frequency voltages supplied from the antennas of each pair, attenuators in the form of high-frequency iron screws were provided.
Thus, the switching device provided switching of each plane once in 1/50 of a second. Looking at the position of the target (e positive or negative), the polarized relays Pr and Pb, the windings of which are fed from the output of the receiver through a low-frequency switch, worked in one direction or another. The contacts of the polarized relays control (depending on the nature of the control system, 2.54) either the antenna control motors for the position of the antenna head or the switching device for the steering bodies of the controlled object. In fig. 61 shows an embodiment for activating the Mg and MW motors with polarized relays. Two potentiometers were installed on the antenna head, which rotated together with the entire head, while the potentiometer sliders were connected to the body of the object. The voltages removed from the potentiometers gave command values for controlling the object. Thanks to the third winding of the polarized relays, which connected to the tachogenerator,
The receiver worked with the LG-20 klystron in super-regenerative inclusion. The super-frequency of 10 MHz was generated by an EF-12 lamp and superimposed on the voltage of the reflector. This could achieve a bandwidth of 50 to 60 MHz (about 0.5%), which was necessary to cover the frequencies of the Maddo radar (about + 25 MHz). The receiver had a sensitivity of approximately 200 kT0.
A particular difficulty of passive guidance on this station was the fact that it - at least with the maximum
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mum of the main petal - could be taken only intermittently (approximately every 2-3 seconds). In reality, the guidance did not take place on a separate radar station, but on the radiation center of an aviation unit in flight and armed with several such stations. With sufficient approximation, the lateral maxima of the transmitting antenna were also captured.
A target exit device, similar to the Max P device, was also envisaged in the case of using the semi-active method (2.562, cf. 3.513.13).
The active homing device “Max A” was intended for installation both on bomber missiles and on fighter missiles (3.525, 3.524.2). He worked with a continuously

emitting transmitter at a wavelength of A = 3.9 cm and a receiving device, which in principle corresponded to the circuit depicted in Fig. 61. In fig. 62 is a block diagram of an active device.

home> proximity

horn — th Executive 1-1 u relay

P and s. 62. Block diagram of the homing device ,, Max A. "

SUPCH - super-regenerative amplifier of an intermediate frequency of 300 MHz: SG - super-regenerative generator of 10 MHz; AGC - automatic level control.

Dielectric antennas for direction finding in two planes according to the method of an equal-signal zone are located

Examples of completed and designed systems 203 were

presented exactly as with the “Max R” device. Since the working wavelength was increased, the diameter of the rods

became correspondingly large (19 mm -). In the center

rods, that is, in the “direction of view” of the head (2.52), a transmitting antenna in the form of a horn emitter made of tin (a pipe with a diameter of 28 mm, a length of 80 mm; a horn with a length of 120 mm, with a smaller diameter of 28 mm, was installed on the antenna plate) large —100 mm). The entire head was covered with a fairing made of insulating material with a slight dielectric constant (foamy needleite). The transmitter generated a continuously radiated power of about 5 watts at a frequency of 7700 MHz. For this, an eight-chamber magnetron LMS-86 was used, which operated with an anode voltage of 500 V and independent excitation of a magnetic field (1600 gs). A small part of the transmitter energy was diverted to the mixing stage (assembled on germanium diodes), where it was mixed with an intermediate frequency of 300 MHz (the intermediate frequency generator was assembled on an RL-12-T1 lamp).

The second mixer received two frequencies from the receiving antennas: one - generated as a result of residual oscillations between the transmitting (horn emitter) and receiving (trolitulum rods) antennas (some of the transmitter's energy is consumed, approximately 10 ^ 6) of the order of 7700 MHz and the other - high-frequency energy, reflected from the object. The frequency of this fraction of the energy was greater than the frequency of the radiated energy by the Doppler frequency (the relative velocities, changing in the ranges V = 120 and V = 600 m / s, correspond to Doppler frequencies in the range 3080-15 400 Hz,
V V
IE f Doppler ~ - / transmitter • Due SMeShIVZ-
AS
NIJ chzstot these two with a frequency of 8000 Mc voznikzlz second mixer the intermediate frequency of 300 MHz,
204,
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Doppler modulated. This intermediate frequency was amplified by approximately 2,000 times and was demodulated by a super-regenerative amplifier (RL-12-T1 with a breakdown frequency generator EP-12). By means of such a scheme for the formation of an intermediate frequency, its independence from the drift of the transmitter frequency was achieved, since the drift of the magnetron transmitter frequency equally affected the frequency of the generator of the heterodyne receiver; Therefore, the constancy of the frequency stability was only the frequency constancy of 300 MHz of the auxiliary generator (the bandwidth was about 600 kHz). As a result of this, the sensitivity of the receiver could be kept at about 100 kT0.
The input high-frequency stage was followed by a two-stage low-frequency amplifier (2-EF-14), in which a transmission bandpass filter designed for frequencies from 3 to 15 kHz and a high-frequency filter with a limiting frequency of 3 kHz were sequentially connected. The low frequency (equal to the Doppler frequency), filtered in this way, was rectified by an EZ-11 lamp and fed to a rotating switch, which provided the distribution of signals to the control relays Pr and Rv. This rectified voltage was also used to adjust the signal level of the superregenerative amplifier, and the time constant of the adjustable circuit was chosen so that the controller responded only to slowly changing field strengths and did not respond to antenna switching (50 Hz) [49].
The unit was powered from a 24-volt on-board network in such a way that current and voltage were stabilized for certain particularly sensitive consumers: the magnetron's magnetic field creation circuit and the klystron glow were powered by an iron-hydrogen barter, other consumers were powered by a 500 Hz converter, moreover, for the anode and reflective voltages, as well as the Venelt voltage for the klystron, the neon stabilization was provided in the "Max R" device.
Examples of completed and designed systems 205
The following values can be indicated as parameters of the homing device "Max" (cf. 2.52):
Angle of view ...................... + 10 °
Installation accuracy ............... + 1 ° i
Installation speed ............... + 30 ° 'Eek.
Range ............... for ,, Max A "-
1-2 km, for" Max R "- 50 km, or the range of optical visibility.
Such homing devices were provided for anti-aircraft missiles (especially for Schmetterling and Wasser Fall, 3.525) and, in some cases, for an air-to-air missile projectile Нв-298 (3.524.2). Since these objects in combat use were supposed to have, in addition to guidance equipment for the target, and equipment for actuating the fuse (2.613), research on the use of the Max A transmitter was carried out taking into account this task. Part of the transmitter energy was supplied to a special

antenna (a set of dipoles providing a circular radiation pattern, cf. Fig. 62). This proximity proximity fuse (2.632.2-2.632.3) was called "Trichter" (see 3.514.21) [49].
During the development of the Max homing devices, some modifications were outlined. If, for example, the output signal was not supplied to the control relays, but to the deflecting plates of the cathode ray tube, and the antenna head was mounted motionless along the longitudinal axis of the aircraft, then the target output device was obtained. This device (passive) was made in several copies [49] and had the name "Corfu-V". It was intended for guiding night fighters at enemy bombers that were armed with the Maddo radar station (Corfu, aka RiMV), and for reaching the Rotterdam station L1, 45].
The next project was to use the device (Schuss-Max) as a sight for firing from on-board weapons, either using an optical pointer similar to the Corfu-V pointer, or by auto
• 206
Chapter 3 of the
math weapon guidance through the antenna head. A system was also developed for the automatic firing of airborne weapons. This system, which was based on the proximity trigger fuse "Trichter", was not implemented (3.514.3).
3.513.13. Moritz (Licht system). The Research Institute of Postal Research conducted studies to create a special radar device for determining the coordinates of the target. The ground transmitter irradiated a flying target; Signals reflected by the target were received by one or several bearing-mountain receivers located at various points. In the Likht system [45, 50], conventional ground-based directional radar transmitters with pulsed decimeter wave radiation were used as ground transmitters. In this case, it was required to continuously direct the transmitting antenna to the target. To avoid the need to constantly monitor the direction of the antenna, first studies were conducted with pulse switching of meter waves and with circular radiation, and then irradiation through a centimeter-wave rotating antenna was considered. In order to distinguish between the signal of the true air target and the slowly moving false targets that could be created using foil sheets ("Dupel" [1]), only those reflected signals were received that were modulated by the propeller.

If, instead of a pulsed radiation transmitter, the work was carried out with a continuous radiation transmitter, then, in addition to the received modulated frequency obtained due to the operation of the propeller, a very low frequency was also adopted, arising from the interference of the transmitting and receiving frequencies, of which the latter differed by
Af = -, where v is the relative speed of the target, reflecting A
signals, and the receiver (cf. 3.513.127) [50].
The Licht system was initially tested for ground direction finding. If the direction-finding receiver was installed on an airplane (night fighter), then we got
Examples of completed and designed systems 207
Semi-active target exit device. This device, working with a 10-watt transmitter according to the continuous mode method [48], was called “St. Moritz”. It was developed by the Postal Research Institute in Moritzburg (Saxony) and was to be used for night fighters in the Vienna area. As an indicator, dual headphones were used, giving an interference tone.
If you replace the acoustic indicator with a relay connected to the receiver output (2.52), then you can use the device for homing purposes. Such a device was called Moritz. Its circuit diagram is similar to the circuit depicted in Fig. 61, only in this case, instead of dielectric emitters provided for centimeter waves, directional antennas of the decimeter range were used. The above mentioned interference frequency Af corresponded in this case to the “Doppler frequency”, which was used in the “Max A” device (3.513.12). Of course, this frequency is lower than in the “Max A” device, due to the longer waves used in the “Moritz” device.
The difficulty in ensuring the normal operation of these devices, based on direction finding by the equal-signal zone method (cf. 2.511, Fig. 35), lies in the fact that the output quantity depends on the difference between the two input quantities, and therefore the corresponding input level strongly affects the sensitivity of functioning. The exact automatic gain control required in this case determines the relative complexity of the receiver. The matter is simplified if, instead of the difference, the ratio of input quantities (antenna voltages) is used. For this purpose, the Moritz instrument for the first time provided a computing device that logarithms comparable voltages (for the logarithms, the characteristic of the rectifier blocking layer was used, which has an exponential dependence to some extent). This achieved a position
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values could vary in the ratio 1: 1000 [51].
It should also be mentioned [48] about the difficulty in using the device, which arose mainly with the semi-active guidance method (2.563). This difficulty consisted in the need to ensure that the homing device responded only to radiation reflected from the target, and would not be directed to a transmitter that irradiates the target. For instruments such as the Moritz instrument, which respond to the interference of direct radiation and radiation reflected from the target, as well as for devices that use only the strength of the reflected signal for direction finding, this difficulty can be easily eliminated.
3.513.14. Special high-frequency homing devices. In addition to the Radischen and Moritz instruments, the Post Research Institute has developed two more high-frequency homing devices [48].
The passive Windhund instrument was supposed, like the Max R instrument, to reach the airborne radar station (Rotterdam and Maddo).
The active device “Dakkel” worked on the principle of direction finding of the return beam (radar) with pulsed radiation of decimeter waves (similar to the active devices for reaching the target “Hoentville”, “Liechtenstein, etc.).
3.513.2. Optical and infrared homing devices. A description of both categories of devices (2.552.12 and 2.552.13) can be given together, since their frequency ranges

follow each other and, moreover, in the design they do not have fundamental differences.
If gas-filled photocells and glass optics can be used in optical devices, then infrared devices require special elements (with cooling) and special optics. The designs of instruments operating in the field of infrared frequencies are better developed than instruments operating in the light frequency range. This was due to the
Examples of completed and designed systems 209
primarily due to the fact that infrared devices have a more universal application (2.57, table. 8).
3.513.21. Hamburg The homing device Hamburg (Fig. 63) was developed by Electroacoustic
. 63. Schematic diagram of the homing device "Hamburg".
in Kiel and Namslau, it was also intended for anti-aircraft missiles, especially Wasserfall missiles (3. 525.13), against air targets, and in some cases could also be installed on dropped objects (3.523) to destroy ground and sea targets [45.1]. It was a passive infrared device, in which a cooled, infrared ray receiving element was provided as a receiver. This item has been specially developed by ELAC. The element was cooled to approximately –80 ° C [48] by means of solid carbon dioxide. Filling with solid carbon dioxide was carried out shortly before use. The sensitive element was located in the focus of a parabolic reflector with a diameter of 25 cm. A shutter in the form of a half circle rotated in the path of the beam between the mirror and the photocell (see Fig. 63 and 64, a).

one revolution (cf. also fig. 61). Thus, the output signal of the photocurrent amplifier was transmitted via a switch to relays (Pr and Rv), which in turn controlled the steering organs, changing the spatial coordinates of the controlled object, or controlled the position of the reflective system. By means of electric control devices, the homing head when a target (infrared emitter) enters its field of view was set so that the optical axis of the mirror (the "direction of the axis of view") turned out to be directed to the radiation source, since only in this case both relay windings could be energized for identical periods of time due to the same periods of illumination of the photocell when the shutter was turned through 180 °. The use of a tracking homing head was necessary,
The Hamburg device practically gave output commands of the yes-no type only (2.311.1, Fig. 10.6). The weight of this device with six lamps was about 10 kg. The range was 3 km [48].
3.513.22. "Madrid". A passive homing device called Madrid was developed by Cap in Vienna and was also intended for anti-aircraft missiles, in particular for the Enzian missile (3.525.12). The reflective system and the infrared-sensing photocell were the same as the Hamburg device, however, the shutter had a quadrant cutout (Fig. 64.6). The principle of operation of the device is the same as that of the Hamburg device. In laboratory tests, the device (in 1945) showed a range of 2-3 km with the number of lamps from 3 to 4. Its weight was 5 kg [48].
The peculiarity of the Madrid device was that it had an electro-pneumatic device for controlling the position of the homing head, at which
the installation speed had to reach 20 ° -,
sec
with a deflection angle of up to + 30 °. The compressed air necessary for the operation of the control device was in a small steel can. There was only enough air for a few minutes of work.

"Hamburg" "Madrid" "Reynmetall-
Borsig"
Emden-Tag "" Emden I "
" EmdenP "
" Linze 2 * 3 1 * 3 Z + k 1 * 3 for one of the two
plane surfaces
Figure 64. Disk shape of various optical and infrared homing devices.
3.513.23. "Army". In an effort to significantly increase the angle of view without turning the head, ELAC has developed yet another passive infrared homing device, the Army. In this device, not a reflector was used, but a lens ball rotating around a photocell at a speed of 16 rpm. As a result of the arrangement of the lenses in a spiral, a strip-like sweep of the target space was obtained, and due to this, the output value was given out in the polar coordinate system in the form of two components, and the characteristic was continuous with respect to the angular 14 *

component, and the relay one was continuous. The angle of view was to be ± 45 °, the range of action - 1.2 km [48],
3.513.24. Rheinmetall-Borzig device. This device also had a spiral scan, however, both components of the output value had continuous characteristics. The device was developed by the Rhine-Metal-Borzig company in Breslau and was intended for the Reintohter anti-aircraft missile as a homing device (3.525.14). The device had two disks with cutouts. The disks rotated in the same direction, but with different

speeds. One disk had a notch in the form of a sector, the other in the form of a spiral slit (see Fig. 64, c). The sweep frequency was 10 ec. The photocurrent amplifier was assembled on four lamps. The angle of view was ± 2.5 °, the range of action was about 3 km. The weight of the device is only 3 kg [48].

3.513.25. "Emden." In one of the research laboratories of the Universal Electricity Company (AEG), a group of homing devices was developed under the general name Emden, some of which worked in the field of visible radiation, and some in the field of infrared rays.

First, an Emden-Tag device was manufactured as a research device. It should have been conducted primarily research on fundamental issues of homing, and especially the issues of inclusion and management (2.512, 2.54). The device also made it possible to carry out studies with various designs of modulating disks, etc. It worked in the field of the visible spectrum and was used for an artificial purpose, which was a light source modulated with a frequency of 5 kHz, so experiments could also be carried out in daylight.

A photocell (cesium) was installed behind the disk, which was made, as shown in Fig. 64 g The disk had two diametrically located opaque quadrants and two transparent ones. The movement of the disk was carried out by means of three eccentrics in such a way that its axis moved in a circle, while the disk itself did not rotate around its axis. The incident light was concentrated by a collecting lens with a diameter of 10 cm.



The DC voltage from the output of a six-amp photocurrent amplifier was supplied via a control switch (see Fig. 63), rotating synchronously with the disk, to a control relay to control the position of the device in two mutually perpendicular planes. The angle of view of the device was ± 20 ° [48].

On the basis of the Emden-Tag device, two more devices were subsequently developed that were to be used against targets that are sources of infrared rays. They had special optics and sensitive elements for working in the infrared region. Special optics and infrared-sensitive elements from ELAC were used.
The device “Emden-I” had control in the polar coordinate system, and “Emden-II” - in the rectangular (1.412). The device "Emden-I" was intended for Hs-293 (3.523.2) and "Schmetterling" (3.525.11); he had a disk for obtaining polar coordinates (Fig. 64.5). The alternator was spinning in synchronism with the disk. The disk was cut in the shape of the Archimedes spiral (r ~ <p), so current pulses appeared in the photocell, the duration of which was proportional to the distance of the target image from the center of the disk. The image of the target was obtained in the form of a luminous point focused in the plane of the disk. The phase of the photocurrent pulses relative to the phase of the sinusoidal voltage generated by the generator was a criterion for the direction of the coordinator axis. This determined the position of the target in polar coordinates. This made it possible continuously (2.311, Fig. 10, e) direct the optical axis of the homing lens to the target. The device “Emden-II” was a modified version of the device “Emden-Tag”. The disk used in this device is shown in fig. 64, e. He made it possible to determine the coordinates of the target in a rectangular system. The disk rotated synchronously with two generators, which fed the circuits of two thyratrons with voltages offset in phase by 90 °. The control of thyratron excitation was carried out from a photocell. The passage of current to the quenching of the thyratron, when the corresponding voltage of the anode became The disk rotated synchronously with two generators, which fed the circuits of two thyratrons with voltages offset in phase by 90 °. The control of thyratron excitation was carried out from a photocell. The passage of current to the quenching of the thyratron, when the corresponding voltage of the anode became The disk rotated synchronously with two generators, which fed the circuits of two thyratrons with voltages offset in phase by 90 °. The control of thyratron excitation was carried out from a photocell. The passage of current to the quenching of the thyratron, when the corresponding voltage of the anode became
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negative, it was a quantity that determines the position of the luminous point (image of the target).
The devices “Emden-I” and “Emden-P” were initially intended to be used only at night. However, the studies showed the possibility of using them also in daytime conditions, for which special blue filters were provided.
In the future, the possibilities of creating an active device should be investigated. For this purpose, the installation of an infrared spotlight on board a managed facility was envisaged. In semi-active use, powerful infrared floodlights were used for “lighting”. “Lighting” was carried out from the ground or from a ship. The difficulty of implementing the semi-active method was that spotlights that had a narrow beam of light (this was necessary for energy reasons) had to accompany flying targets, therefore, it was also necessary to accurately determine the coordinates of the target relative to the spotlight location.
3.513.26. RT-101. The passive homing device “RT-101” was the next version of this class of devices. It was developed on an optical basis by the Aviation Research Institute in Berlin. The device was designed to homing the falling PC-1400 or SD-1400 bombs, similar to the Fritz-X remote-controlled bomb (see 3.523.1), onto ships.
The RT-101 had a photocell and a disk, however, it could give output signals only for “yes – no” commands, which were supposed to control the steering organs of the bomb. In each of the control channels there were thyratron circuits. The grid voltages of the thyratrons were removed from the potentiometer, which was controlled from the aneroid box and thus affected the adjustment of sensitivity depending on height

(distance from the target). By means of a high-altitude switch, control was automatically turned on at a height of 4000 m and control was turned off at a height of 200 m [29].
3.513.27. "Lince". Principle developed by GEMA in conjunction with AEG passive homing device-
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The name, called “Lince” or “Wasserlinsee”, was applicable for both visible radiation and infrared.
Initially, it was designed only for automatic control in one plane (for firewalls). The photocell was installed behind a rotating modulating disk, which for modulation was equipped with two concentric rows of slots (Fig. 64, g). The number of slots in the rows was different.
Depending on which series of slots the light beam focused by the lens fell from the target, a signal of a higher or lower frequency was obtained at the output of the photocurrent amplifier, which was supplied to the control devices through the corresponding filters.
Thanks to the installation of two modulating disks with a different number of slots, as shown in Fig. 64, h, four overlapping fields are formed, each of which determines two frequencies from four possible modulation frequencies. From the amplifier output, such a mixture of frequencies was supplied to the filtering stages. From the allocated frequencies it was possible to judge the direction of the axis of the device1. These signals could be detected by means of relays or other elements and used for control according to the “yes - no” principle. This rather complex system was simplified by the fact that instead of two modulating disks, one was installed (Fig. 64, and). Two opposite quadrants of this disk modulated the radiant flux at one frequency, and the other two at two different frequencies, different from the first. By means of a switch (Fig. 63) control commands were distributed according to different frequencies on the control channels. A device with a three-lamp amplifier at an angle of view of + 3 ° should have a range of about 3 km [48].

3.513.28. "Cottbus". While in all infrared devices considered so far, photocells were used as a detector of radiant energy, two more passive self-ordered devices ordered by the military * were in development -
1 In two planes. - Note ed.
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reference: “Cottbus C” (Klassen firm), which was performed by analogy with the Hamburg device
(3.513.21), but instead of a photocell, had a thermocouple [45.1], and “Cottbus Z” (Zeiss company ”), Which had a bolometer as a sensitive element. At first, experimental devices made it possible to receive commands in only one plane [45.1].
3.513.29. “Lichtautomat G”. Finally, one more device should be mentioned, which was fundamentally different from the ones considered above, because its peculiarity was that it should not directly respond to the energy radiated (or reflected) by the target, but only to the contrast that the target illuminated by daylight had light (for example, the contours of the target compared to the environment), that is, was based on the so-called contrast control. At first this device, “Lichtautomat G”, was intended for automatic homing of bombs on sea targets. It was designed around 1941 in the laboratory of the steel company Golnov und Zon in Stettin. Leading engineer Dr. Ramba-uske, after stopping work in this laboratory, continued to develop his initial plan at other institutes and, by the way, at the Research Institute of Physics, Dressenfeld [9, 48]. However, the device was never brought to the state of suitability for practical use. It contained an iconoscope with a spiral scan of an electron beam. In the iconoscope, the target stood out due to the contrast with neighboring image points, so that in the place of the image of the target, a pulsed change in the current of the iconoscope was obtained. If the target image coincided with the center of the photocathode, then the control command was absent. When the target point was shifted, by means of comparison with the phases of the corresponding reference voltages, continuous commands were issued corresponding to two control planes. Since the viewing angle of the iconoscope was only ± 3 °, a rotating reflector was also used. The angle of rotation of the reflector at However, the device was never brought to the state of suitability for practical use. It contained an iconoscope with a spiral scan of an electron beam. In the iconoscope, the target stood out due to the contrast with neighboring image points, so that in the place of the image of the target, a pulsed change in the current of the iconoscope was obtained. If the target image coincided with the center of the photocathode, then the control command was absent. When the target point was shifted, by means of comparison with the phases of the corresponding reference voltages, continuous commands were issued corresponding to two control planes. Since the viewing angle of the iconoscope was only ± 3 °, a rotating reflector was also used. The angle of rotation of the reflector at However, the device was never brought to the state of suitability for practical use. It contained an iconoscope with a spiral scan of an electron beam. In the iconoscope, the target stood out due to the contrast with neighboring image points, so that in the place of the image of the target, a pulsed change in the current of the iconoscope was obtained. If the target image coincided with the center of the photocathode, then the control command was absent. When the target point was shifted, by means of comparison with the phases of the corresponding reference voltages, continuous commands were issued corresponding to two control planes. Since the viewing angle of the iconoscope was only ± 3 °, a rotating reflector was also used. The angle of rotation of the reflector at It contained an iconoscope with a spiral scan of an electron beam. In the iconoscope, the target stood out due to the contrast with neighboring image points, so that in the place of the image of the target, a pulsed change in the current of the iconoscope was obtained. If the target image coincided with the center of the photocathode, then the control command was absent. When the target point

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sec.

[48]. The reflector turned due to the commands issued by the iconoscope through a complex control device. To simplify the system, the possibility of using wide-angle optics was provided. Despite this, the system remained very complex: 9 lamps and an iconoscope, and the consumed voltage was 1000 V!
It is also worth mentioning the attempt to use the “Tonne” television camera (3.512.11) of the Fernseee company in Berlin for automatic homing using the contrast control method.
3.513.3. Acoustic homing heads (2.522.2). Here you should consider: firstly, the heads used on aircraft, that is, acoustic air heads, and secondly, acoustic underwater heads for automatic control of torpedoes. The main difficulties, especially for the heads of the first type, consisted in the fact that the planes, and especially the missiles, in the hull of which the homing heads were to be mounted, created significant noise of their own, which was supplemented by the noise from the airflow around the flying projectile.
A further drawback of the speaker systems is associated with the insignificant velocity of distribution of sound waves (approximately 330 m / s) in the air. Due to this, the direction being directed to the sound source at the moment of arrival of sound waves does not generally coincide with the direction to the target even with known circumstances.
1 These provisions apply to acoustic detonators firing at a certain distance from the sound source (3.514.23), however for them they can be smaller, since the required radius of action is much smaller, and accordingly the pressure of the useful sound waves acting on the sensitive elements of the fuses is higher.

In such cases (especially when the object moves very fast), the flight path of the object receives a greater curvature and length compared with objects equipped with heads operating on the principle of using an electromagnetic field.
Acoustic air heads worked exclusively on the principle of the passive method (2.561) and, therefore, were applicable only for targeting with powerful sound

radiation. Active acoustic air heads (2.562) due to the low density of sound waves in the air can hardly be created. Experiments were carried out to create active acoustic underwater heads (Gayer, see 3.513.35).

3.513.31. "Dog". The Dog homing head developed by Telefunken after preliminary research by Dr. Kramer (Rurshtal) was specifically designed for installation on an X-4 air-to-air projectile (3.524.1). Since this rocket rotated during its flight around its own longitudinal axis, it was enough to have two microphones for direction-finding alternately in the azimuthal angle and elevation angle. The distribution of signals along the longitudinal and lateral channels was carried out using a switch stabilized by a gyroscope (see Fig. 92, 93).
Both microphones were located at a distance of about 70 cm from each other (the diameter of the X-4 missile body was 22 cm) in separate fairings, which had several holes in the same plane around the same plane for receiving sound waves (Fig. 65). The most appropriate shape of the fairings and the most advantageous arrangement of such openings were selected after several preliminary studies in order to ensure the minimum pressure of acoustic noise (this minimum of acoustic noise almost coincides with the zero zone of equal pressure).
Fig. 65. Installing a microphone in the homing head “Dog”.
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Due to this, the pressure on the microphone from the side of acoustic noise decreased to about 1 μbar (at a frequency of 100 Hz this amounts to approximately 60 background), which provided a range of up to 1000 m with a source of useful sound waves with a gradient of 1000 μbar per 1 m. X-4 acoustic noise was reduced to the required minimum (in some cases, it was necessary to resort to turning off the drive motor at the time of transfer of control to the acoustic homing head) [48].
The ratio of the useful acoustic signal to the interfering effects reached the optimum value in the frequency range from 100 to 200 Hz. Because of this, the head was designed so that its own resonant frequencies lie outside this region. The source of useful sound waves (the engine of the target aircraft) had a maximum radiation in the frequency range of 100 Hz. However, due to the Doppler effect, the frequency of sound waves acting on the microphone was higher. Tuning the system to a relatively narrow frequency range (the frequency spectrum of the sound wave source is much wider) was caused by the need to obtain distinct phase relations between the signals of both microphones, which were used as sensitive elements of directional action. Two identical amplifiers working on a phase discriminator were connected to the microphones. The rectifiers of the latter turned on in the opposite direction and produced an output current whose strength turned out to be proportional to the deflection of the target (Fig. 66). The angle of view should have been approximately + 30 °.
P and with. 66. Functional diagram of the homing head “Dog”. FD - Phase discriminator.
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3.513.32. "Suite". This homing head was created by the Imperial Post Research Institute in Würzburg. It was intended for installation on anti-aircraft missiles (3.525). Since the latter did not rotate around its longitudinal axis, separate direction finding was required along two coordinates. Four directional microphones were mounted in the head, which, in order to compare the amplitude values of the output signals, were alternately connected to one common amplifier using a rotating switch (see. Fig. 61). Due to the low frequency of the received signals, the switching frequency should have been chosen sufficiently low. Whether the large time constants due to this were permissible should have been clarified in the course of experimental studies, which, however, were not completed by the end of the war.
3.513.33. ELAC homing head. This passive acoustic homing head was designed by Electroacoustic in Kiel and was a further development of the heads with the signal switching mentioned in the previous section. The head had four dual microphones with four separate amplifiers. Two dynamic microphones of the same group were connected

electrically to the input of one of four amplifiers built on 3-4 lamps. All four groups of microphones had to be mounted on four probes spaced 25 cm apart; if possible, microphones should be placed in the zone of minimal acoustic noise. Using systems of rotating fields and ring modulators at the output of the channel amplifiers of both control planes, it was necessary to determine the phase difference, which was used to form the control signal. Moreover, according to ELAC [48], direction finding accuracy of up to 1 ° was achieved at a viewing angle of ± 90 °. However, this implied the presence of four double amplifier microphones with the same characteristics (in amplification and phase shift). In order to realize all these conditions in the homing heads used in practice, it was necessary to overcome significant difficulties.
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3.513.34. Heads “Tsaunkënig” and “Lerche”. The homing head “Tsaunkënig” was intended to aim underwater torpedoes at the target. It was developed by a special torpedo commission under the guidance of prof. Küpfmüller, several firms participated in the commission, including Atlas-Werke in Bremen. As sensitive elements, the head had two magnetostrictive vibrators that were installed in the head of the torpedo (Fig. 67)

Fig. 67. The receiving part of the "Tsaunkönig" acoustic homing head located in the torpedo head.

Thus, the main maxima of their wedge-shaped directivity characteristics shifted in the horizontal plane with respect to the longitudinal axis of the torpedo by + 30 ° [14]. The low-frequency voltage created in the sensitive elements under the influence of sound waves emanating from the target ship's propeller was amplified and rectified. The control signal obtained by comparing the output values of the individual channels acted directly on the governing body (rudder) of the torpedo. With it, the torpedo navodi-

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familiarize the target curve by chase (2.53) from the rear hemisphere (hence the bolts).

The homing head "Tsaunkönig" was successfully used in the last years of the war. With its help, several destroyers were destroyed. As a protective means against torpedoes with this head, which worked according to the passive method, artificial sources of acoustic interference ("dummies") soon began to be used from the enemy side, which were towed behind the ship or, if necessary, were simply thrown aft [14].

Similar means of protection (see also 1.221.2) would be effective against objects equipped with a Lerche passive acoustic head. At the same time, an annular vibrator with a frequency of 35 kHz was installed in the head of the torpedo on the basis of a funnel made of sponge rubber, which created a beam of size 1A horizontally and 3 L vertically1.

Therefore, it was a question of finding the location of the source of sound waves (target) to the maximum (2.412.32). The received signals from the target were transmitted via a wireline to the control point (to a submarine) [46]. The wires of the communication line (up to 6 km long) when the torpedo moved ran from the coils. They served simultaneously to transmit control commands (see NYK system, 3.511.25).

3.513.35. Gayer. In order to make the use of the simple means of protection mentioned above (artificial sources of interference) ineffective, at the end of the war an active acoustic homing head was developed for torpedoes, which was named "Gayer" [14]. For this purpose, in addition to the receiving pair, a transmitting pair of magnetostrictive vibrators was installed in the torpedo hull, emitting sound wave pulses in the horizontal plane. Impulses reflected from large objects should have been taken by the receiving part of the homing head.

3.514. Remote fuses and automatic fuses. Key points about the device

1 According to Dr. V. Kunze, Atlas-Werke, Bremen.

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these instruments are contained in section 2.6. Here we restrict ourselves to a brief mention of the fuses created and planned in connection with specific projects of remote control systems.

3.514.1. Remote fuses. These include all devices for which remote information transmission is used to initiate individual processes (2.612), for example, electric ignition of explosive charges of all kinds via a wireline or the already mentioned command to stop the V-2 projectile engine via a radio link (3.522, Fig. . 79), as well as the aforementioned device for igniting a charge at a distance of the explosive carrier B-4 (3.526.12).

The Kel – Strasbourg radio control system (3.511.12) also created a device for ignition of a charge at a distance (FuG-203 L / 230 a), in which, in addition to the four modulation frequencies, the fifth low-frequency generator, which was switched on by pressing a button, was provided ("Fuse sensor") and formed through the subsequent low-pass filter - in the receivers "Strasbourg-N", "Marburg" or "Colmar" (3.511.13) - a

command to ignite the explosive. This device was supposed to be used to ignite the charge on gliding bombs (Hs-293 and others) and on fighter missiles (air-to-air projectiles) Hs-298 and Hs-117 if the projectile passed the target. It was also possible to command the ignition of the explosive also in the Kog-ge radio control system (3.511.14).
3.514.2. Automatic fuses. Just as this was done with respect to homing systems, in this case the devices must be systematized in accordance with the forms of energy used (2.622). As for the difference between remote fuses and proximity fuses, it was already mentioned in section 2.621 (see also table 13).
3.514.21. High frequency fuses. Only
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such a fuse, which was in serial production, was called "Cockatoo." It was designed and built by the company Donaulandisch Apparathebau in Vienna and was intended for installation on anti-aircraft and fighter missiles. The fuse had a transmitter emitting electromagnetic waves with a frequency of 600 MHz, and a receiver which, using a receiving antenna (mounted together with a transmitting antenna), received electromagnetic waves reflected from the target with a frequency of about 600 MHz. When the received and transmitted signals were added together, a “Doppler frequency” was formed (3.513.12–13), the passage of which through a zero value was used to give a command to ignite the explosive. Thus, the Kakadu fuse acted as a “proximity fuse” (2.632.2 and Fig. 38). Similarly

The Doppler effect was also used for the Trichter proximity fuse, which was to be used with the Blaupunkt-Werke Max homing device in Berlin (3.513.12, Fig. 62). Moreover, to fire the fuse at the moment of its passage at the minimum distance from the target (2.632.2) [49], the radiation pattern of the antenna device (a series of dipoles with a disk-shaped diagram in a plane perpendicular to the direction of flight (L = 3.9 cm) was additionally used The oscillator feedback effect was used in the FuG-380 fuse system, the excitation of the oscillations should have been disturbed when approaching the fuse antenna of an electrically conductive target (airplane), there was a change in current in the anode circuit of the lamps s vibrational cascade, which was used to excite the desired process [46].

On the principle of the device of the low-altitude meter manufactured by Siemens FuG-101, the Marabu remote fuse was designed specifically for anti-aircraft missiles [46, 47]. He used sawtooth frequency modulated oscillations, which after

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reflections from the target were superimposed in the receiving device on the transmitted signal, so that the output voltage was obtained with a frequency directly proportional to the distance to the target [1]. Depending on whether the fuse's actuator relay triggered when a certain frequency was reached or when the minimum frequency passed, either a “remote” fuse or a proximity fuse was obtained. All of these devices were active fuses. Passive high-frequency fuses were not designed, because when pointing at the enemy’s radio transmitters there was no certainty that the latter would not be turned off when approaching the target. The problem looks different if it comes to the execution of certain commands, such as when flying over a transmitter that specifically emits vibrations for this purpose, staying on when you approach a telecontrolled object. This case includes, for example, contacts “Fühler” (“Sensor” [65]) -

they are mentioned in Section 3.6, which were intended to be switched when flying above the transmitters during a program flight (Table 17, numbers 6/7, 8/9, 10/11, 11/12).

3.514.22. Optical devices. This type includes the Pistole remote fuse developed by the Universal Electricity Company [46]. It had a light source (an infrared radiation source was not excluded), placed inside a rotating cylinder equipped with slots, so that the modulated light was radiated in the radial direction (perpendicular to the direction of motion). If a reflecting body (target) appeared near the device, then the photocell perceived reflected rays, and then an executive relay was activated through an amplifier and a low-pass filter.

3.514.23. Acoustic devices. The X-4 fighter rocket (3.524.1) was equipped with a very simple acoustic remote fuse (Maize) developed by Dr. Kramer (Rurshtal firm in Brakveda). The housing of the projectile (. Figure 91) was placed a microphone that when approaching projectile definite

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the distance to the source of sound waves - the engine of the aircraft (130 background) - generates a signal required for direct actuation sensitivity * Foot switch that was supposed to cause a shell explosion. To select the microphone location, the positions marked for the homing head “Dog” are valid (3.513.31, see note on page 217).

Similar passive devices were also experimentally installed in freely falling shells that did not have an engine, and were used in small quantities for air defense purposes. In the latter case, the fight against bomber formations flying in close formation was carried out by dropping bombs on the center of the enemy aircraft building from fighter bomber flying above.

Here, mention should also be made of acoustic detonators for sea mines, which were

triggered by the passage of ships with propellers working over them (sources of sound waves).
The fact that remote control technology can be used not only to ignite an explosive, says recently started in Germany the use of acoustic remote “fuses” as “overtaking alarms” for trucks and road trains. Devices are placed in the driver’s or driver’s cab and are triggered when a sound signal comes from behind vehicles.
3.514.24. Static devices. The remote and proximity detonators we have examined so far have used the energy of electromagnetic or acoustic radiation (2.522, 2.622), however, several devices have been developed along with them, in which stationary fields were used in contrast to homing devices (2.551).
The active device, which was supposed to be triggered by the disturbance of the electrostatic field, was a proximity condenser fuse created by the Universal Electricity Company. The flying object had a probe fixed in the insulator (a rod about 1.5 m long, installed in front of the bow Hs-293, Hs-

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, etc.), the capacity of which relative to the housing was "measured" using a high-frequency bridge circuit. When approaching a conducting electric current (or dielectric) body, the effective capacitance increased and the imbalance of the bridge was used to ignite the charge.
A similar device designed to use a magnetic field was called the "Isegrim" [46]. In it, to detonate a fuse, a change in the mutual inductance between two coils was used when approaching a conducting electric current or having a magnetically permeable body. The well-known magnetic fuses for sea mines and torpedoes worked according to this principle. In order to ensure ignition of the explosive in the event of a miss, a magnetic fuse was also used in the planning ("diving") bomb Hs-294 (3.523.3).
For operation of a passive electrostatic remote fuse "Kuglokke" an electrostatic charge of the aircraft had to be used [46].
Concerning passive magnetostatic devices, there was an opinion that large-sized airplanes form significant dispersion magnetic fields due to the currents flowing through their extensively branched on-board network.
It is necessary to make one more brief remark about the firing distances of automatic fuses.
Since the destructive effect of the charge is proportional to r (r ~ 3 is the distance to the target), you should choose the firing distance depending on the magnitude of the charge. Therefore, using remote fuses to achieve maximum effect, you must pay attention to the fact that they do not work prematurely. Because of this, it is generally necessary to give preference to proximity fuses that fire only when the projectile passes a point located at a minimum distance from the target (2.621). At the same time, it is necessary to strive to reduce the delay time of the fuse, as far as possible, since during the operation the distance to the target starts to increase
again. Automatic 16 *
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fuses designed to destroy aircraft, the operating distance varies between 4 and 12 m, that is, an average of about 7 m.
3.514.3S Other automatic executors of special teams. In addition to the already mentioned automatic fuses, there were a number of designs of devices with which it would be possible to initiate other processes using similar technical means. As the most important of them, we name projects of devices for the automatic opening of fire from firearms. When installing a proximity fuse on the earth with an upward radiation pattern, the Tiffligerfall device was obtained — a modification of the Trichter device of Blaupunkt-Werke (3.514.21, 3.513.12) [49].
Similar equipment should have been used on fighters to automatically open fire from airborne weapons when flying from above or below an enemy aircraft, since at very high relative speeds the "effective" excitation of the desired process with the help of hands becomes practically impossible.
The universal electricity company developed the Zossen infrared device specifically for installation on Me-163 fighter jets [45.1]. The ELAC passive infrared device Wünsdorf, together with the Blikrichtung device, had to be mounted on attack aircraft at the bottom of the fuselage in order to automatically open fire from downward-pointing guns at tanks and steam locomotives [45.1].
Finally, we also mention the project of the Ebbe device, which was developed by Telefunken in cooperation with the railway department. The device was supposed to serve for the electric detonation of railway mines and was to some extent a combination of a fuse operating at a distance and an automatic fuse. Radiation of electromagnetic energy was carried out using a short-wave transmitter located at some distance from the mine, and energy transfer to the fuse for its operation occurred automatically during movement.

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train systems 229 above a mine [45]. Thanks to this, it was possible to control the explosion arbitrarily and even after laying mines to pass any number of trains across the section.
3.52. Projects of remote-controlled weapons
In this section we will consider the most important examples of remote-controlled weapons developed in Germany during the Second World War. At the same time, a brief overview of the projects is given at the beginning and, in conclusion, the features of some technical solutions are described.
3.521. Projectile Fi-SW, or V-1. This aircraft, which was most widely used during the war compared to other types of long-range jet weapons, although it was not telecontrolled, should be considered as an example of a fully automatically controlled aircraft.
3.522. Long-range missile A-4, or V-2. It is also mainly an autonomous entity. But it should be touched, since part of the equipment used was equipped with devices for telecontrol in the plane. Moreover, the technique of ensuring movement along a certain trajectory and the formation of a command to stop the drive motor is within the framework of the issues considered here.

3.523. Remote-controlled bombs "Fritz-X" and Hs-293, which were mainly used as actual remote-controlled aircraft.
3.524. X-4 and Hs-298 air-to-air remote-controlled fighter missiles.
3.525. Remote-controlled defensive projectiles (to repel fighter attacks).
Comparative data for the aircraft weapons mentioned here are given in Table 15, where an attempt was made to classify them according to the sections 1 and 2 of the first chapter of systematization.We have already briefly considered (3.526) some of the projects of German remote-controlled weapons (see also 3.32, table 10)
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3.521. Projectile Fi-103, or V-1. This winged projectile was created in a very short time in 1942 by the Fieseler aircraft manufacturing company in Kassel under the direction of the German Air Force Directorate and was tested at the Peenemunde-West test site. To keep all the work on its creation a secret, he was conditionally named “Kirshkern” and received the code name FZG-76.
Fig. 68. Autonomous guided missile aircraft V-1
(Fi-103).
After the first combat use on June 12–13, 1944 [9, 11, 25], in addition to the Fi-103 trademark, he was given the designation Fau-1 (V-1, where V (fau) is the first letter of the word Vergeltung - retribution, retribution).
The main data shown in Fig. 68 and 69 shells [8, 25]:
Total length ........................... 7.73 m
The largest diameter of the fuselage .......... 0.82 m
Wingspan ......................... 4.9 m
Starting weight .......................... 2,2 / and
Payload .............. ....... 1000 kg (explosive charge)
Direct-flow engine WFD (Schmidt pipe, German patent of 1931 [9]) of the Argus engine-building plant in Brandenburg.
Fuel ....... low-grade gasoline.
Tank capacity .. about 600 l.
Flight speed of about 160 m1sec. Range of about
250 km.
For some later shells, the maximum range was increased to 370 km [11].
Accuracy is approximately 4x4 km with a range of 250 km.
The Fi-SW start was carried out using an accelerator launch unit made in the form of a tubular catapult with a gas-vapor drive (the catalytic decomposition of hydrogen peroxide was used). At launch, the projectile experienced an acceleration of 21 <7 (206 m / s2), while the flight speed reached about 86 m / s. At this speed, it rose to a predetermined height (see below), so that in a subsequent horizontal flight a speed of 160 m / s was developed. Launching installations required large construction costs.
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Many concrete pad on the coast of the English Channel in 1943, according to the Anglo-American plan "Cross bow" [11 ] were subjected to serial bombing from the air. During the tests, and by the end of the war and in combat conditions, projectile shells were launched from carrier aircraft (Me-111). One prototype of such an aircraft for flight with a crew was also created.

Fi-SW production bombs were equipped with an automatic stabilization system with respect to three axes (2.23 and Fig. 7), which was created by Askania-Verke in Berlin. A gyroscope driven by compressed air, which was corrected for the course by a magnetic sensor, served as a deviation sensor from the set course. While for most of the shells the course was set by the direction of the launch and remained unchanged for the entire duration of the flight [2.21], by the end of the war, individual samples began to be equipped with reversal devices, so that after the start of the projectiles, the projectiles could perform a turn according to the program (2.251).

The flight altitude could be established by a barometric sensor in the range of 200–3000 m (2.222). To determine the distance to the target, a track counter (“air lag”), set in motion by a small propeller, was placed in the bow of the object. Upon reaching the pre-calculated distance from the launch site, the track counter turned off the engine, simultaneously issued a command to the elevator and the projectile was transferred to a dive flight.

Part of the V-1 shells was equipped with radio transmitting devices, so that using cross-direction finding it was possible to track the flight path and determine the location of the projectile's fall (by the termination of the transmitter).

Preparations for the serial production of the projectile began in 1943 at the car factory in Fullersle-ben. From June 1944 to March 1945, only 9,300 V-1 shells were fired at targets in England, mainly in London. Many shells were also fired for other purposes [8, 11, 12, 25].

3.522. Long-range missile A-4, or V-2. Not-

Undoubtedly, the most famous of all the models of remote-controlled weapons was the German long-range missile A-4, which after the first combat use in September 1944 received the name V-2 (V-2). This object was one link in the creation of a number of so-called “Units” (A ...). As early as 1932-1933, the construction of the A-1 unit was begun. The first attempt to start a liquid-propellant engine with a thrust of 300 kg (a project by the Armed Forces Arms Directorate) was made at the Kummersdorf artillery range on December 21, 1932 [11]. The A-1 projectile had a starting weight of 150 kg, a length of 1.4 m and a maximum diameter of 30 cm. To stabilize the longitudinal axis, a heavy flywheel weighing 40 kg was installed in the head of the projectile. Since the head of this aircraft was heavier, then the gyroscopic body was moved to the central part of the projectile. Following the first unit A-2, equipped with the same engine, in the first tests on the island of Borkum in December 1934, it reached an altitude of 2.2 km with a duration of engine operation of 16 seconds. [8, 11].

In March-April 1936, it was decided to create a joint center for the development of missile weapons for aviation and ground forces. It was then in Peenemünde that the Peenemünde-Ost Army test site and the Peenemünde-West Air Force training ground arose, where further studies and tests were carried out, and even the production of shells at the Peenemünde Ost training ground. In Kummersdorf, further types of shells were developed - units A-3 and A-4. The first experiments with them were carried out even before the creation of test sites in Peenemuende in December 1937 in the Greifswalder-Oye forest, located on the island of Usedom. The A-3 projectile had a size of 6.5 mx 0.7 m and a starting weight of 750 kg (the experimental model had no combat charge). A rocket engine with a thrust of 1.5 m and a duration of 45 seconds was installed on it.
Weight b * (kg) From (ka) It (not) 1
12800 6796 1000
A-9 16 260 mto then
A'U A-9
? A-Sf II in
8-o6 total weight (starting) vg-ees of fuel vnesh useful load
1st stage action rocket Engine thrust (at sea level b
1st stage (ACh) 200000kg
2nd stage (A ~ 9) 25400 kg
Unit 4
27000 kg
Fig. 70. Sectional view of long-range missiles A-4, A -9, A-10.
The A-9 projectile is a modification of the A-46 projectile (A-4 with wings of small sizes to increase the range), it has, with the exception of the stabilizing planes, the same dimensions.
Examples of completed and designed systems 235
damping gyroscopes and acceleration sensors. The A-3 shell also had a parachute for landing registration equipment, as well as a radio receiving device, which, if necessary, received command signals to stop the engine.
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Fig. 71. V-2 (section).
The design of the first A-4 rocket, which was supposed to have a warhead weighing 1000 kg and an engine with a thrust of 25 tons, was already begun in 1936-1937. But before you get a chance to start its design, it was necessary to find an extremely
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many individual issues. Therefore was created and passed multiple tests another missile A-5, which had a braking parachute and parachute reduction,
Fig. 72. V-2 on a transport trolley.

what ensured its accident-free descent after the combustion of all fuel. This unit was driven by the engine of the A-3 rocket, despite its slightly larger outer diameter. In addition, start-ups were also built.
Examples of completed and designed systems 237
repaired (partly from an airplane) various models of reduced sizes. With their help, all those numerous problems were clarified, which made it possible to carry out the construction of a large rocket. They concerned primarily the stabilization of flight speeds in the subsonic and supersonic regions, the size of steering machines, aerodynamic and gas rudders (replacing molybdenum rudders with graphite ones reduced the cost of building a rocket by 100 times) and much more. The weight of the experimental A-5 rockets with the presence of additional equipment reached almost 900 kg. The ceiling was 12 km, and the flight range was 18 km [11].
Along with the creation of the V-2 projectile in Peenemuende, other models of guided weapons were also designed. In particular, rockets [8] were built as prototypes: A-4, A-5, A-6, A-7, A-8, A-9, and A-10.
The A-4b missile is actually an A-4 missile equipped with small wings to increase the flight range. In January 1945, several such missiles were fired.
One model of the A-5 rocket, equipped with wings for experimental studies of the planning flight after being dropped from the aircraft, received the name A-7.
Rocket A-6 was a missile project to study the possibilities of using various types of fuel.
The A-8 rocket was a transitional structure from A-4b to a rocket with A-9 bearing planes, which together with the first stage, bearing the designation A-10, was supposed to form a two-stage long-range missile (the so-called "America-Rocket"). This project was under development as early as 1941.
The A-10 unit as the first stage of a composite rocket was to weigh 87 tons, spend about 62 tons of fuel in one minute, and due to a thrust of 200 tons, inform the rocket of the first stage A-9 starting speed of 1200 m / s. At the end of the operation of its own engine, the A.-9 rocket had to reach a speed of 2800 m / s (10 000 km / h!) And rise to a height of 55 km, after which it had to be completed in 35 minutes in a planning flight. cover a distance of about 4100 km [11].
Fig. 73. The start of the long-range missile A-4 (7 points).

However, let us turn to reality. We give the basic data of the A-4 rocket (taken mainly from the source [11], see also [8, 9, 10, 25]):
Total length ................. ...... 14 m
The largest diameter of the fuselage ...... 1.65 m
The span of the planes of the stabilizer .... 3.55 m
Starting weight ............... ....... 12 900 kg
Payload weight ............. 1000 kg
Explosive weight (in the warhead
) ............ ............ 750 kg
Weight of the rocket without fuel and combat charge 4000 kg
Mass ratio .................... 3.22
LRE engine with thrust (at start) 25 t.
Fuel ........................... ethanol + liquid oxygen
1 3965 kg of alcohol (75%) + water (25%)
4970 kg of oxygen 181 kg of hydrogen peroxide and potassium permanganate (for pump drive)
Steam-gas turbine
power for pump drive ............ ...................... 680 l. from. at 5000 rpm
The total productivity of two pumps is 127 kg / s The volume of the combustion chamber, including the exhaust nozzle ............................ ........ approximately 0.8 m3
Nozzle diameter ................................. ......... about 74 cm
Pressure in the combustion chamber ................. 15,45 ata
Temperature in the combustion chamber ........ ..up to 2700 ° C
The velocity of the outflow of gases ..................... 2050 m1sec
Draft
preliminary stage ............. ..8 t
starting ........................................... 25 t
before engine shutdown ........... about 30 t
Engine running time ......................... about 1 min. Energy
reserve
of the fuel mixture ................. about 1600 kg cal / kg of the
total amount of fuel .......... about 6-10® kgm
Average effective power ........... about 4 • 10® l. from.
Acceleration
at start ....................................... about 0.9 d
when the engine stops ................. 5-7 d
Maximum flight speed ... 1600-1700 m / s Kinetic energy at the time
of engine end about 5 • 10 kg kg
Live impact force ............................. about 2 • 108 kgm
The temperature of the outer shell .. up to 700 ° C



Flight ceiling
for vertical launch .........
when launching at a maximum range of about
190 km
.........
Range of action Flight time .....
80-100 km 250-350 km for about 5 minutes The
start of the A-4 took place vertically. In this case, the rocket was installed freely on the launch pad 4x4 m in size, equipped with a device for deflecting a gas stream. After 3 seconds engine operation at the preliminary stage (8 tons of thrust) the cable that

fed the rocket’s electrical equipment before start was disconnected from the gasoline unit and the main engine stage (25 tons of thrust) was simultaneously turned on. During
4 sec the rocket rose vertically upward with an acceleration from 0.9 to 1 d. In the next 50 seconds. the longitudinal axis of the rocket slowly tilted “forward” until the angle of inclination of the trajectory with respect to the vertical of 45-50 ° was reached. Over the entire life of the engine, equal to about 1 minute, the acceleration due to a decrease in the weight of the rocket due to fuel combustion and due to the increase in thrust from 25 to 30 tons due to a drop in external atmospheric pressure increased to 127 m / s2. At about the 25th second, the flight speed reached the speed of sound. Upon reaching a precisely set speed (about 1600 m / s, Ma <5), thanks to the command to end the engine operation (see below), the oxygen supply was stopped and the pumps stopped. Starting from this point (approximately 24 km horizontal and 22 km vertical from the launch site), the rocket flew like a ballistic projectile. After returning to the troposphere, the rate of fall due to air resistance decreased to 900–1100 m / s. As control bodies (1.422), aerodynamic rudders placed on four stabilizers were used, which were mechanically connected to four graphite gas rudders (see Fig. 71): the rudders were driven by hydraulic steering machines (see Fig. 6). During the climb and until the aerodynamic rudders have sufficient speed for effective operation of the aerodynamic rudders, control was carried out exclusively with the help of gas rudders; Further which were mechanically connected to four gas rudders made of graphite (see. Fig. 71): the rudders were driven by hydraulic steering machines (see. Fig. 6). During the climb and until the aerodynamic rudders have sufficient speed for effective operation of the aerodynamic rudders, control was carried out exclusively with the help of gas rudders; Further which were mechanically connected to four gas rudders made of graphite (see. Fig. 71): the rudders were driven by hydraulic steering machines (see. Fig. 6). During the climb and until the aerodynamic rudders have sufficient speed for effective operation of the aerodynamic rudders, control was carried out exclusively with the help of gas rudders; Further



right up to the engine stopping, both sets of rudders worked together.

Normal equipment of the A-4 rocket included a system of automatic stabilization with respect to three axes, which was carried out using two gyroscopic devices with potentiometric sensors. The control around the transverse axis was carried out by two “elevators” moved in one direction, which were driven through an electric differentiation link and a direct current amplifier from a “horizontal gyroscope”, which had a cardan suspension and connected to a double potentiometric sensor (see Fig. 74) [ 26.6, 71].

The gyroscope potentiometer was moved using a clockwork relative to the longitudinal axis of the rocket according to a certain program (2.251), so that thanks to automatic control the rocket described the desired trajectory in a vertical plane and after about 50 seconds. after the start, it took a slope of the longitudinal axis of approximately 45 ° relative to the vertical (see above). Likewise, the so-called “vertical gyroscope” also actuated rudders, but they served only to hold the rocket at a predetermined course

(2.21). A vertical gyroscope simultaneously allowed automatic stabilization of the position of the rocket relative to its longitudinal axis (2.23). For this purpose, another double potentiometric sensor was placed between the universal joint ring and the pin [26.6]; the voltage removed from this sensor caused the "rudders" to move in opposite directions, which was achieved by the specified stabilization. The accuracy requirements were the same as for high-altitude and lateral control, since rotation of the object around the longitudinal axis due to programmed elevator control would lead to a deviation of the rocket from a given course.
Instead of those indicated in fig. 6 mechanical damping devices (feedback and a damping gyroscope), to control the A-4 rocket, electric differentiating links were used around any of the three axes
16 Telecontrol
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, as shown in Fig. 74. Their task was to transform the ratio of (complex) voltages U2 / IV in such a way that the output voltage U2 is ahead of the input voltage Uj
Given _ direction of the failure axis (vertical at start) Gyroscope
housing _ Rocket longitudinal axis Housing D / A Amplifier - ----- "- ------------
DC main axis project

Potency brush-Mempajm kosyazataya., .1 meters with universal joint1 ring
Fig. 74. A-4 rocket elevator control with the help of a "horizontal" gyroscope
minimized overshoot during the transition process, since this requirement had to be met for a wide variety of flight conditions (from
V = O to V = 6 s2 with a simultaneous change traction force, moment of inertia, air density and the position of the center of gravity), a number of problems ensued, which are
1 More precisely, the transfer function. - Ed. * a - speed of sound. - Ed.
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followed allow to receive optimal stabilization quality (for details, see 26.6).
Since the damping element, in addition to a temporary shift in voltage changes, also caused a significant decrease in the value of the output voltage U2 (at a = 0 more than 40 decibels) in comparison with a relatively low input voltage (due to the use of small loads of potentiometers), it was necessary to ensure reliable moving the spool of the steering machine to carry out a large amplification of the DC signal.
As a DC signal amplifier, a "ring modulator" was used in conjunction with a low-frequency amplifier (Fig. 75) [7.3].
Fig. 75. Amplification of the DC signal by a "ring"
modulator.
KM - ring modulator.
The accuracy of angular stabilization using only gyroscopic control was about + 1 °, the corresponding lateral deviation from a given trajectory was ± 4 ... 5 km per 250 km of luti. Longitudinal dispersion, due to inaccuracy in setting the angle of inclination of the longitudinal axis relative to the vertical,
U2
was smaller, since the function r = - sin 2? (g -
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firing range,? - the angle of inclination of the longitudinal axis) at? = 45 ° has a flat

maximum. The “initial flight speed” F0, that is, with regard to a rocket with an engine, has a particular influence on the accuracy of range shooting, namely the speed at which the engine turns off and the projectile begins to follow a ballistic parabola (since F0 is squared).
To reduce lateral dispersion, in addition to the gyroscopic control, part of the A-4 missiles also introduced azimuthal control using the guiding beam method (2.32). While gyroscopic control could eliminate only the angular deviations of the rocket from a given position, control by the method of the guide plane came into effect when the center of gravity of the projectile deviated from a given vertical plane. The method used to create the guide plane is considered above (2.321.5 and 2.322.2). The operating principles of a terrestrial radio system (“Hawaii”) are briefly outlined in 3.511.16 (see Fig. 49): switching a voltage phase with a frequency of 50 Hz supplying two horizontal dipoles; recognition of both radio beams in two modulation parts (D = 5 kHz; / 2 = 8 kHz).
Lr
G1
HFPR hfd
5 s 50
kHz,
filter
LF
N
Filter
“Ring” module r
? - To the regulating * * device
Differentiating
Link
Fig.
76. Block diagram of the control receiver according to the guiding plane method for rocket A-4.
HFPR - receiver ; VCHDM - demodulator;
LFDM - low-frequency,
[demodulator.
A-4 control receiver according to the control plane method and implemented in accordance with the circuit shown in Fig. 76 [71]. Depending on the sign of the deviation of the rocket from the guide plane at the exit of the "ring ”Modulator a positive or
Examples of completed and designed systems 245
negative DC voltage, which, after the differentiating element (similar to that shown in Fig. 74), was summed with the signal from the “vertical” gyroscope (Fig. 77) [26.6, 73].

PrN
And
Converter '
ПЦГ
Д32 КМи У нчг
ЕНнМЕ
I *
? 1 - 0
500 Hz
? I
RM
. Rudder
'directions
DZ,
KM, ULF
kmg
Fig. 77. The control system of the lateral channel of the A-4 rocket using gyroscopic control and control according to the method of the guide plane.
PCG - gyroscope potentiometer (see Fig. 75); PrN - control receiver according to the guide plane method (see. Fig. 76); DZ - differentiating sound; ULF - low frequency amplifier; RM - steering car (see rns. 75); KM - “ring” modulator (KMt or KMg, see Fig. 76, KM, in PrN,
see Fig. 77).
The scheme was calculated so that the lateral displacement of the rocket by several meters from the guide plane caused the steering machine to move at full speed. The test results initially showed no improvement in lateral control compared to simple gyroscopic control. This was due to the fact that the guide plane created by the electric method due to the distortion of the radiation pattern by the roughness of the surrounding area and the uncertainty of reflection from it was not identical to the geometric plane symmetrically located between the ground antennas. The indicated difficulty could be eliminated only with. using artificial “earth” in the vicinity of the transmitting dipole and accurate research by measuring the radiation pattern. The costs associated with these activities would allow the use of the guide plane method in front-line conditions only when stationary launch pads were created. An improvement was also expected as a result of
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Chapter 3 can be
used instead of ultrashort waves with a base of 200 g of the decimeter wave range with a narrow radiation pattern (see 3.511.16). Despite the fact that experimental studies of guiding by the directing plane method were started back in June 1941, no satisfactory solution was found until the end of the war, as a result of which 4,300 V-2 shells used at the front using a guiding beam were fired only 20% [11].
The second difficulty was that even with minor rocket vibrations during transient processes around an axis lying in a vertical plane at an angle of 90 ° to the longitudinal axis of the projectile, noticeable lateral deviations could appear, since the directly available direction of the velocity vector at the time the engine stopped for all subsequent flight time. This required a great deal of theoretical and experimental work aimed at obtaining the optimal parameters of differentiating links. In any case, lateral deviations of less than ± 2 km were not reliably provided even in 50% of the missiles launched.
And finally, the last technical task related to telecontrol was to provide a command to stop the engine at the right time. As indicated above, the main problem was the accurate measurement of flight speed. Here are some observations about accuracy: when considering the pri-

Vr
given above ballistic equation g - - sin 2s
I
for the case when the point of incidence and the starting point (in our case, the engine stopping point) are in the same horizontal plane, we saw that longitudinal dispersion of ± 2 km, with r - 250 km, corresponds to an accuracy of ± 0.8%, which requires a tolerance by speed about + 0.4%. With F „= 1600 m / s this will be ± 6.4 m / s. Since the rocket experienced an acceleration of at least 5 d, or about 50 m / s2, therefore, it was necessary, firstly, to measure the instantaneous speed with an accuracy of at least 6 m / s, and secondly, to make a time-accurate shutdown engine (accuracy not less than ± 0.8%). The last requirement is somewhat easier-
Examples of completed and designed systems 247
It was that shortly before reaching the required value of F0, the engine throttled to an acceleration of about 1 d, and its final stop occurred later.
The measurement of flight speed could be carried out in various ways: by determining the speed on board (2.431) by integrating time acceleration; using external devices (2.432), using the Doppler effect that occurs when superimposed high-frequency oscillations emitted from the earth are applied to oscillations associated with the first and reflected on-board systems.
In the first case, the command to stop the engine was sent directly from the integrating device (2.611.2), in the second - it had to be transmitted from the ground command transmitter to the airborne command receiver (2.612).
As integrators of the device: one is purely in which
two mechanical (according to Givers) accelerations were used to measure the gyroscope precession [71], accelerations were used and the second was electric (proposed by Prof. Buchhold and Wagner), where the acceleration was converted into a proportional electric current d, and the value of the flight speed V was determined by the amount of electricity in the electrolytic cell (speed V = \ bdt p t idt - the amount of electricity) [73].
Doubler

P-41 transmitter frequencies . __ t
On-board installation
21
Bridge • Frequency measurement unit
Af
Stop valve for engine stop
I \ Receiver | control commands
Transmitter of the control command
“Ring” Command command repeater modulator Terrestrial installation
Fig. 78. Measurement of flight speed and engine shutdown using ground-based means,
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The method based on the use of the Doppler effect (according to Shteblane and Wolman) was outdated and was associated with high costs. The principle of operation is briefly explained using fig. 78 [71, 73].
Onboard object moving away from the terrestrial transmitter at a speed V, received vibrations with frequency
V
that / '= / (1 - -), where C = 3 • 108 m / s (speed of light,
see 3.513.12). In the on-board transceiver, this frequency doubles, that is, oscillations are again radiated with a frequency of 2 / '; then the ground-based receiver receives a signal with a frequency
By comparing with the frequency 2 / directly connected to the receiver, we get at the output of the receiving device the “Doppler frequency”
L / = 2 / - / "= 4 / |,
which is a measure of the flight speed of the rocket relative to the ground station. / = 30 MHz and V - 1500 m / s we get
1 5 • 103
Aft * 4 • 30 • 106 'sec-i = b00 Hz.
3-108 *
The error due to neglect of the quadratic term is only 2.5 • 10_v. The Doppler frequency is measured by a bridge circuit and, when a predetermined speed is reached and corresponding to engine shutdown, it triggers a relay that activates a command transmitter (or its modulating device, see Fig. 11).
To transfer the command aboard the projectile (Potsdam-Berlin) [46], a method similar to that used in the Kel-Strasbourg telecontrol system (2.312.24 and 3.511.12) was used. Contact receiver output relay powered small controlled solenoid valve, which opened the access
Sample system 249 and designed
compressed air to the main valve of the oxygen system (1.423.1).
The methods discussed here have found further application for monitoring the flight path over the radio (2.422, 2.432), which was carried out by installing several (3 or 4) receiving devices in various places (for more details see [26.8, 71, 108]).
To reduce the longitudinal dispersion even more, it was necessary to make the moment the engine was turned off dependent not only on the flight speed, but also on the distance traveled by the rocket. This was caused by scattering due to traction and other similar factors that were not associated with unambiguous functional relationships with the absolute value of the speed. Several methods were developed to control the path traveled by the rocket from the moment of launch (for example, double integration of acceleration 8 = JJ bdt2), but they were not brought to ready-made structural solutions.
The above allows us to conclude that the creation of the A-4 rocket, considered as a whole, is an extremely large technical achievement, in which telecontrol issues

constituted only a small part of the overall task.
Concluding the description of these missiles, I would like to emphasize the fact that those people, thanks to whom we have this great technical achievement, did not at all set the task of creating any kind of weapon. They were forced to subordinate their plans to military purposes only under pressure from the authorities.
The extent to which such shells are valuable for research was clear from the very beginning of the work on the projects [11], but this was proved only after the war, and not in Germany, but in the USA. There, captured German A-4 rockets were used to study the upper atmosphere1; Carrying measuring instruments instead of a charge, they reached a height of 190 km. The A-4 rocket was used there as the first stage of the Bumper two-stage high-altitude missile, the second stage
1 In addition to research purposes, German samples and missile patents were used in the USA directly to create guided weapons. - Note ed.
250
g lava 3
which, the American 300-kilogram rocket VAK-Corporation, reached an altitude of more than 400 km in 1949 (the maximum flight speed was about 2700 m / s). The view of this composite rocket, the total mass ratio of which was 7.3, is shown in Fig. 79.
Fig. 79 Two-stage rocket "Bumper" = A-4 + "VAK-Corporation
."
3.523. Remote-controlled bombs. They can be divided into two main types: a) telecontrolled falling bombs that are dropped from high altitudes after conventional aiming, and their flight path is only corrected by telecontrol; b) planning bombs equipped with bearing planes are dropped from the aircraft from medium altitudes and reach the target in the planning flight. Here will be considered the mass-produced and widely used German telecontrol bombs Fritz-X and Hs-293 (see also [97]). At the same time, we briefly dwell on some related systems. For other projects in this area, see 3.526.3.
For both types of bombs controlled with respect to two axes, the continuous command method (2.312.3) was used.

The Kel -? Strasburg system with the FuG-203/230 installation (see 3.511.12) was used as a serial radio control system. For factory tests and tests directly in aviation on several He-111 aircraft, a radio transmitting part of the FuG-203 control system was installed. In combat conditions, this control system was tested on 330 military aircraft such as Do-217, Fu-200 and He-177, which took on board
1 to 4 Fritz-X or Hs-293 bombs (FuG-203 d ... /), These bombs were dropped and aimed sequentially one after another. Towards the end of the war, the latest combat aircraft were equipped with telecontrol installations, but these vehicles were not used in combat.

In the case of the use of radio interference from the enemy's side, the air units armed with the indicated types of bombs had complete sets of equipment for switching to wired control lines (3.511.22 and 3.511.23); however, they turned out to be unnecessary, since no serious radio interference was observed. For the same reason, the transition to other frequency ranges was not used, for which it was envisaged to use S 203-1, S 203-2 systems as transmitters. Excluding some cases of combat use against ground targets, both types of bombs were used exclusively for destruction of marine objects. Between 1943 and 1944, telecontrolled bombs sunk ships with a total displacement of more than 400,000 tons, as well as a large number of warships, especially destroyers, with direct hits of up to 40% [12, 15].

3.523.1. The falling bomb is SD-1 4 00 X, or "F r and c - X". Back in 1938, at the German Aviation Experimental Institute, the design of automatically controlled, or more precisely, remote-controlled airborne objects was started under the leadership of Dr. Kramer [30]. Due to the fact that on these bombs the wings were not mounted crosswise but X-shaped, they received the designations X-1, X-2, etc. These developments led to the creation of the remote-controlled falling bomb SD-1400X, or "Fritz-X" which the company Rheinmetall-Borzig began to produce in 1941, Berlin — Marien-



felde. The tail part of the light metal bomb with the radio part of the control system mounted in it was manufactured by the Electric Installation Society (GEA), Stuttgart-Felbach.

Fig. 80. Remote-controlled falling bomb ,, SD 1400X "(" Fritz-X ").

The Fritz-X bomb (Fig. 80) had the following basic data (25):

Total length ........................ 3.2 m
Weight armor-piercing bomb SD 1400 .... 1400 kg
Maximum body diameter ...... about 70 cm The
location of the wings ............. X-shaped
wingspan ....... ............... about 1.6 m
Engine ........................... no
height dumping ................ 4000-7000 m
Maximum fall rate ..... about 280 m [sec.
Accuracy of hit (50%) ......... area 5x5x

The main purpose of the bomb was the defeat of warships with powerful armor (linear

1 The accuracy of the hit is apparently greatly exaggerated. - Note ed.



ships, heavy cruisers, aircraft carriers). Preliminary aiming was carried out using a normal bomber sight (Lotfe-7s or Lotfe-7s1) in a straight flight of a carrier aircraft, on which there was a radio transmitting part of the control system (Kel, see below) along a straight path. Opening the bomb suspension locks was carried out either manually by pressing a button or automatically using the "target passage contact" mounted on the bomber sight. The guidance was carried out by the optical covering (registration) method (2.412.11), that is, after the bomb was dropped, its free fall path was only

adjusted so that the conditions of the optical registration of the bomb and the target were constantly satisfied.
Mr. _________
eschdya aircraft carrier
trajectory of the targets 02 468
Fig. 81. Guidance falling bombs "Fritz X" on the cover method (in the vertical plane).
Fig. 81 shows a combination of a number of direct lines to the vertical plane passing through the trajectory
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tory aircraft flight (apart from that, the bomb was managed and plane perpendicular to the direction of flight.) At the same time, the points at which the plane, bomb and target are located are denoted by the same numbers [97].
As control organs, plates were used to ensure the disruption of the air flow, or the so-called interceptors (1.422.42), which were installed in the tail unit and were driven by double electromagnets. In fig. 82 shows the location of such a device in the tail shell of the Fritz-X bomb [30].
An interceptor 100 mm wide, protruding alternately from the upper and lower profile plane (600x105 mm, 60% safety margin, thickened trailing edge), was suspended on a spring and connected to a flat (later insulated) electromagnet anchor. The displacement of the interceptor was only 2-3 mm. At a switching time of about 5 ms, the energy consumption of the electromagnet was 1-2 watts. Switching Frequency -

5 Hz (T - 0.2 sec., See Fig. 20). Since the natural frequency of the object was below 1 Hz, the control action of the periodically switching interceptors (2.312.24) was averaged in accordance with the command value (Fig. 21). Protruding edges
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interceptor systems are sometimes made in the form of a ridge. Slots in the tail plating were sealed with rubber.
In total there were three pairs of such dual interceptors. Their location is shown in fig. 83. This figure is a rear view of the rear of the bomb in the direction of its longitudinal axis [97].
End
Fig. 83. Placement of interceptors in the tail of the Fritz-X bomb.
Such a scheme made it possible to control in the Cartesian coordinate system (1.412.1) with respect to two axes, namely, “left – right” (lateral control l – n) and “up – down” (“high-altitude” control n – n), using direct connection (2.312.11) of the corresponding group of interceptors to the output of the radio receiving part of the Strasbourg control system (3.511.12, Fig. 48). Of course, in order to maintain the invariable position of the interceptors (2.23) relative to the spatial coordinates, the bomb should not rotate around its longitudinal axis during the fall. For this purpose, two more interceptors were placed on the horizontal stabilizer, which were controlled by a gyroscopic device in such a way that their movements were directly opposite to each other, which achieved stabilization relative to the longitudinal axis. The gyroscopic device consisted of two gyroscopes: positional, which did not turn on before the bomb was dropped, and damping (direction indicator, cf. Fig. 6). The diagram of this on-board installation is shown in
Brake tube (isolated, vert. L \ 'used' like an antenna]
Antenna device
Tail planes
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Chapter 3
wife in Fig. 84. A 24 V on-board battery and a converter that creates a high voltage to power the lamp anodes were placed in the battery box (VK - 230). The latter, like the Strasbourg receiver (E-230), was placed in a container (AR-230) suspended on springs.
Left-
? Right.
Up
\
Down Left
. Right.
Fig. 84. Schematic diagram of the radio reception FuG-230a control.
at the back of the bomb. Four “brake pipes” were used as an antenna (see Fig. 83), which were supposed to limit the bomb's fall rate so that the characteristics of the control object remained stable and the interceptors effective. The gyroscopic device and the power converter of the gyromotors were also mounted in the rear of the bomb body, which had a cylindrical shape.
At the rear end of the bomb, a light was placed (a pyrotechnic kit or a searchlight with a color filter), which facilitated (or even made it possible) the operator to monitor the fall of the object. Possible degrees of brightness of the illuminator were provided, which could be installed before dropping the bomb into
Examples of completed and designed systems
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depending on the lighting conditions (day or night, and possibly also at dusk) with the help of a special switch located on the plane.
To explain the interaction of the aircraft transmitting part of the control system (FuG-

203) with the receiving on-board control system of the object (FuG-230 ^) in Fig. 85 is a schematic diagram of the system as a whole and a brief summary of the principles of its operation is given below [97].
Remote control \ switching}
p gt
, n— (Jan
Transmitting part of the control system
V? Through the pre-guard
Reception part '' '""' '*' 1 of the control system
Fig. 85. General diagram of the control system for the bomb drop “Fritz-X” . ”
17 Telecontrol
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When the operating switch 1 is turned on, the modulation part M F, the transmitter L (8-203) and the receiver Pr receive power for lamp glow from the on-board battery of the aircraft (24-28 V). At the same time, the gyromotor converter starts to rotate and the gyroscope G starts, which accelerates to the full speed one minute after switching on. When the switch was switched to position 2, the transmitter transmitter (VU / S) received power, and through the selector switch for the VOP object, the receiver converter (PPr) and the DK command sensor (Ge-203). This completes the preparation of the facility for discharge. If you now press the bomb reset button (you can use the contact of the bomber sight instead), then the relay for triggering the gyroscope RrH will work, the longitudinal axis of the gyroscope (the cardan ring of the positional gyroscope) will no longer be connected directly to the bomb body and at the same time the contact rg will close. In this case, the reset electromagnet activates, opening the bomb suspension lock and the bomb falls. When it falls, the disconnect switch PB switches the bus “+24 V” of the receiving part of the control system from the plus of the aircraft’s onboard network to the plus of the onboard battery of the telecontrolled object. Through the selected “day-night” switch, the sliding contact of the SK switches on the corresponding set of illuminators — day OD or night OH. When it falls, the disconnect switch PB switches the bus “+24 V” of the receiving part of the control system from the plus of the aircraft’s onboard network to the plus of the onboard battery of the telecontrolled object. Through the selected “day-night” switch, the sliding contact of the SK switches on the corresponding set of illuminators — day OD or night OH. When it falls, the disconnect switch PB switches the bus “+24 V” of the receiving part of the control system from the plus of the aircraft’s onboard network to the plus of the onboard battery of the telecontrolled object. Through the selected “day-night” switch, the sliding contact of the SK switches on the corresponding set of illuminators — day OD or night OH.
The described principle of operation of the control is greatly simplified, especially in the transmitting part of the system. So, for example, the selection of an object was carried out not using the selector switch of the GP, but through a special multi-pole circuit breaker, indicated by crosses on the diagram. The VOP selection switch and the 0–1–2 operating switch were located on one remote control (SchK-203) and were mutually locked. The reset was also carried out not directly with the reset button and contact rg, but through the relay, which worked only if the gyroscope had been arrested before the reset. Further, the high voltage was supplied to the transmitter only from the moment of the reset, and during the first second after the reset, the electromagnetic energy emitted by the transmitter was significantly attenuated due to the resistance in the AP antenna device

(AGS-203); the timing mechanism (ZG-203) was triggered by the rg contact to avoid overmodulation of the receiver.
The command sensor used to control the Fritz-X bomb (Ge-203; Kel 1) had two rollers (Fig. 46, left), which were driven by a 24-volt motor with an adjustable speed of n = 300 rev / min The DC command sensor was installed in close proximity to the bomber sight in the front cockpit of the aircraft so that it would be convenient for the scorer (operator) to use it. The sensor had a control handle that was held by the spring in a vertical position. When the handle was moved up — down or left — to the right, the contacts of the rollers shifted in the axial direction, which created the corresponding command values in the range –l = s = s –f-1 (see Fig. 21).
As an aircraft transmitting antenna, the PA used two conductors stretched between the fuselage and the vertical part of the tail unit, which were powered by the S-203 transmitter through a 60-ohm high-frequency cable and the AGS-203 antenna device. The receiving antenna of the PrA bomb was connected to the input of the receiver through the antenna device AGE-230a (at the same time it was used as a balancing weight), a 60-ohm cable and a high-frequency plug. The antenna device was located in the tail stabilizer (Fig. 84).
In order to avoid reducing the capacity of the on-board battery from the effects of low temperatures during long-term flight at high altitude, the hardware compartment in the rear of the bomb was heated with hot air (from the aircraft through a hose). The temperature in this compartment was monitored by a vehicle resistance thermometer. Instruments indicating the temperature in the hardware compartment of the bomb were combined on a temperature board.
The E-230 radio (Strasbourg) could be replaced by a receiver of control signals transmitted over the Detmold E-238 wire line. On-board coils with a wire of 8 km in length were to be mounted on both sides of the bomb on the tail washers (Fig. 84, see also 3.511.23).


For functional verification of both the entire system and individual units, the following control devices, ready for use in combat conditions, were available in the required quantity:
Transmitter ......................
Battery box ................
Voltmeter .......................
Receiver ...... .................
Bursting plug ...............
Panels, training equipment, etc.
Before the combat use of the Fritz-X bombs began in the spring of 1942, the German Aviation Experimental Institute (DVL) conducted special tests at the South training ground in Foggia. Most successfully, this weapon was used on September 14, 1943. A direct hit from an altitude of 6400 m sank the Italian battleship “Rome” [12, 25]. In addition to the X-1 design described above, other projects were developed at the experimental institute. So, for example, the interceptors of an object rotating around a longitudinal axis were controlled [30] (similar to control in an X-4 rocket, 3.524.1), homing heads were created (Radishen, 3.513.11; RT-111, 3.513.26 [29]), as well as a remote-controlled 2500-kilogram bomb (X-5 [9]).
3.523.2. Hs-293 Planning Bomb 1.
Planning bomb is a small aircraft carrier explosive (1.221.1). The project of the Hs-293 remote-controlled planning bomb was developed in 1939 in Schönefeld (near Berlin) by Professor Wagner at the Hen-Shel aircraft manufacturing plants. These weapons were mass-produced and in a very short time became a significant threat to

the enemy. The first design was followed by a number of modifications and subsequent developments. This section is devoted to the description of normal constructs of Hs-293a with remote control by radio or, respectively, Hs-293b with remote control by wire. About other bombs developed by Henschel,
rs-sh,
RVK-Sh, PV-Sha, RE-203,? FmP-203,
1 In the domestic literature, such objects were called "air torpedoes". - Note ed.
Fig. 86. Remote-controlled gliding bomb Hs-293.
Sluggish * RU *
Combat
charge
: G: ':
ih'UCl'ncodjli.l ШК i) / h <tiUOoll- ^ U: v l
3jfcsr tpL4 »cctiau open:? -,:. of ^ v Hole Am I r * oihi shtd?> a t Jlpeb /
ipajvcHimcfib flpitejwmtH
d '/ tepm
J'JYO
3 / n Vi ptstmanshshy nps <fii> 8 Elaine
Engine Ru / shshya Aiaui ^ ftLi nyayayasg ni
Lngpsssh
Steering wheel / honeycomb
RF / operator
OceeiT-'t / nU'jfo dsAMipftwwt young? dong (gmichegyo: :) o: Tftjn f'USt
Fig. 87. Remote-controlled bomb Hs-293.
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briefly indicated in the next section (3.523.3). Planning bomb Hs-293 (according to [9, 25]). The warhead is the 500 kg SC-500 mine bomb. In the middle part of the bomb, flat wings with ailerons are attached, the tail unit is a stationary vertical stabilizer at the bottom and a high horizontal stabilizer with a rudder of 1,600 cm2.
The main data is as follows:
Total length .................................... 3.4 m
Largest fuselage diameter .................. 48 cm
Wingspan .......................... ....... 2.90 m

Total weight (without fuel) ......................... 722 kg
LRE engine (cold) Walther 109-507 [9]
length .... ................................... 2,28 m
maximum diameter ........ ................ 35.6 cm
empty engine weight ........................ 64 kg
full weight .................................. 133 kg
average thrust .......... ..................... 590 t
engine operating time ....................... about 10 sec
fuel ......................... hydrogen peroxide
("T-dam") + calcium permanganate ("Z-dam") Drop
height ... .............. from 400 to 2000 m
Flying speed ____ about 320 km / h Fd 90
m / s
Speed at the time of
engine shutdown ....................... approximately 170-200 m / s
Planning range ............ . from 3.5 to 18 km
Accuracy of hit .......... <...... within 5x5 w (with
a planning range of 12 km)

The wings were mounted on a tubular spar passing through the entire body of the bomb at the required installation angles. In addition, to ensure proper stability, a balancing weight was located in the head of the bomb. At the ends of the wings, two cone-shaped “resistance bodies” were attached (they are absent in Fig. 86 and 87), which could be replaced by coils with a wire for remote control via a wire communication line (3.511.22) (see Fig. 52). A “dashboard” was mounted on the lower base of the bomb body, on both sides of which were mounted control system equipment: a 24-volt DEAC battery, a gyroscope, a converter for powering the gyromotor, and



the so-called “articulation device” SAG-230, in which there were filters, relays and similar devices (Fig. 90). This pertinax panel was covered by the shell of the tail of the projectile, which carried the plumage, the pitch channel steering machine and the illuminator. The engine was mounted under the bomb using a three-point suspension. It was fixed in such a way that the axis of the nozzle passed through the center of gravity of the entire object, approximately at an angle of 30 ° with respect to the longitudinal axis of the bomb. The jet engine was activated due to the fact that the electric explosive capsule destroyed the membrane of the starting valve and thus opened up access to compressed air (150/32 am) for fuel supply
[9].

The bomb was intended primarily for the destruction of unarmored and lightly armored ships (auxiliary ships, destroyers, light cruisers). In contrast to aiming when dropping the falling bombs, in this case, the approach to the drop site was not carried out along a straight path in the plane passing through the target point, but at a certain angle to it, as shown in Fig. 89. To determine the relative position of the target during the guidance process, the optical covering method (2.412.11) 1 was also used here.

Fig. 88, a shows a projection of the flight paths of an airplane and a bomb on a horizontal plane; in fig. 88.6 shows the projection of the same trajectories on a vertical plane, and again several rays of the cover are depicted [97].

As governing bodies, the Hs-293 had aerodynamic rudders (1.422.41), namely two ailerons at the trailing edges of the wings (1230 cm2) and an elevator (1600 cm2), see Fig. 87. Ailerons were alternately deflected

x During the combat use of bombs, the object and target were observed by the operator with the naked eye, so that the range, especially with poor visibility, was limited. To increase the range, an optical device such as a telescope equipped with a

double sight should be used so that one operator continuously guided the target to the target, while the other, using the second sight, carried out remote control of the object.
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at full swing with the help of two electromagnets mounted in the wings. Return to the neutral position occurred under the action of springs. The switching frequency was 10 Hz. The elevator was moved by means of an electric steering machine, which was installed in the rear part under the elevator.
April 23 0 1 5 6 7 89101112
6) The vertical plane
reset point
meeting point
(n --- "in
ogtp
a) Gorizantalnaya plane
trajectory bomb tele
Fig. 88.
Trajectory of the target.
Guiding the planner using the covering method. Hs-293 Bomb
Point

The interaction of the ailerons and elevator made it possible to carry out telecontrol in the polar coordinate system (1.412.2), in which the direction and value of instantaneous acceleration (in a plane perpendicular to the line of sight) needed for correcting the trajectory of the bomb were developed, see. 47, c. The Ge-203, e command sensor used for this purpose (Kel-III) had two rollers (Fig. 46), which rotated at a speed of 600 rpm. The movement of the contact lever is carried out- Examples of completed and designed systems 265
It was moved by the control handle, which turned in a movable joint of such a form that the transition from control in the Cartesian coordinate system to control in the polar system occurred already in the command sensor. In this case, the aileron control contact was shifted along the shaft in proportion to the angle of rotation of the control handle (± 135 °), while the second contact moved in proportion to the tangent of the angle of rotation of the handle; the zero position of the control handle is vertical, not fixed by any spring. The command sensor was installed on the right side in the front cockpit of the aircraft so that the operator using it had a clear view forward and to the right; in connection with this, the flight path before the drop went to the left of the target, and the plane turned to the left, to avoid entering the anti-aircraft fire zone, covering the target after the bomb was dropped, Fig. 88 a.

The onboard remote control system of the carrier aircraft was basically the same as for controlling the Fritz-X bomb (Figs. 45 and 85): Kel III (FuG-203, Kommersant) and subsequent ones (see 3.511.12 and 3.523.1).
Anteyny
in
3% § а ч h? 0 В и *, а: -й.0-О “О” О 5 3 О. S. = s
с: к
Feedback of channel of height I
- ^ M ^ === F = the elevator
Ailerons
-back communication crepe
gyroscope
Fig. 89. Block diagram of the receiving part FuG-2306 control system for Hs-293.
Flowchart mounted on Hs-receiving portion 293 of the radio control system FuG-230b is shown in Figure 89. The fundamental difference compared with the Fritz-X on-board control system (Fig. 84) was that the latter had the contacts of the output relay
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the nicks were directly triggered by the operation of the interceptors (open control, 2.312.11), while the Hs-293 bomb executes commands by a closed control system (2.312.12), that is, through the intermediate switching on of the ASG-230 control device between the E-230 receiver "Strasbourg" (like the FuG-230a) and steering wheel drive. With this control, therefore (see Fig. 16-18), from the received values of the control command / Cx and the electric signal proportional to the position of the object (or, accordingly, the position of the steering wheel), a new value of the command / Cr1 is formed, which is always equal after the execution of the control command to zero. For the applied control in the polar coordinate system (Fig. 47, c) this means
The principle of operation is explained in Fig. 90, which reproduces the circuit (functional) diagram of the control receiving part on the Hs-2932.
We first consider the elevator control channel 3 (the deviation of the rudder determines the acceleration value): the contact px of the output relay of the receiver sends rectangular pulses to the Fu filter, the constant component of which and the variable component of the fundamental harmonic of 10 Hz are separated from each other and fed to the polarized relay (G-relay ) P3. Contact p3 of this
1 mismatch signal. - Note ed.
2 In fig. 90 for filters Фг and Фа (see L / C, Fig. 23, a) and for the feedback link there is one double potentiometer
(see Fig. 23.6). This circuit corresponds, in principle,
to the ASG-230 commercially available control device. Firstly
structures (ASG-30), instead of the aforementioned relays, high-power electronic tubes EL 12P 10 were used,
as well as an old-style receiver E-30 (3.511.12). To
reduce the weight of the control device (about 20 kg), due to the weight of the chokes with iron, there were attempts to switch to R / C filters (2.312.24).
8 The described actuator according to the principle of operation is similar to the well-known relay servo system with a tachogenerator. - Note ed.
G G Regulator ~!
Steering wheel height J +1 // 'n
II pp
ev.
right
_ Connector location ~ '& - (THROUGH the break- + plug)
Fig. 90. Schematic diagram of the receiving part of the telecontrol system for Hs-293.

the relay alternately turns the steering gears on the left and right rotation, while the anchor coil is constantly connected to voltage
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direct current. Motor M moves the elevator through the helical gear of the VP and at the same time the brush CKi of the double 2 PT potentiometer, the brush SK (using the second roller rotating in the opposite direction) moves in the opposite direction. The voltage applied to the coil of relay P3 depends on the position of the brushes. Suppose that a control command K = 0 was issued from the output contact of the receiver rg and that the elevator is in the extreme position n (bottom). Then the brush CK is on the left, and the brush CKz is on the right end of the potentiometer, and the relay p3 is activated so that the contact p3 is shifted down. Thanks to this, the elevator channel steering machine rotates at full speed. In this case, the brush CKi moves to the right, and the brush CK2 moves to the left, the relay P3 starts to shift, and the initial closing time for the contact of the right rotation is longer, than for the left. This process continues until the brushes, and with them the elevator, reach the "middle" position, that is, until the control command is executed (see Fig. 23). From this moment on, relay P3 is shifted symmetrically and the motor receives alternately pulses for right and left rotation, however, due to mechanical inertia, it is not able to respond to them. Due to this, however, the accuracy of establishment (steering position according to the command) is significantly increased, since the rest friction is replaced by the motion friction1. In addition to the rigid feedback provided by the CKi and CKi brushes, high-speed feedback (by derivative) is also provided due to the series connection of a voltage relay proportional to the angular speed of rotation of the elevator channel steering machine. This is achieved by turning on a small generator (TG tachogenerator) connected to the steering machine. This "damping" maintains a satisfactory transient during the processing of the control signal and prevents the occurrence of large deviations in the regulation.

1 The so-called vibrational linearization occurs. - Note ed.

Since the rudder efficiency depends on the flight speed V, the angle of deviation of the rudder should depend on it. This is carried out using a pressure sensor of the SDS, made in the form of a plate located in the streamlined stream, which moves the brush SK3> thereby changing the position of the elevator in steady state at a certain value of the control command. The direction of the acceleration height created by the rudder is determined by the transverse position (relative to the longitudinal axis) of the flying object (Fig. 47.6).
The object roll is set in the same way as the elevator is deflected, only feedback is not carried out by the position of the governing body (rudder), but by the position of the transverse axis of the object in space: contact P2 of the output relay of the receiver through filter Ф2 activates relay P4, contact p4 of which by means of two vacuum relays BPi and BP2 alternately turns on the electrons of the ailerons EMu and EM2. In this case, feedback is rigidly implemented through the potentiometer of the gyroscope GHG, and damping is carried out with the help of RaK, which simultaneously works with vacuum relays
A voltage proportional to the angular velocity of rotation of the object ®y (around the longitudinal axis), on the resistance Bi occurs due to the fact that the capacitor C is charged through the resistance B2, which determines the time constant and the steady-state value of the voltage across the capacitor; the latter, through the contact ra, is alternately connected to and “-” of the on-board battery. If, for example, contact p4 gives the “left roll” command, then BPx is activated and 9Mt is attracted, causing the left aileron to deviate upward by a full angle, while the right aileron remains in the neutral position. Then the object rotates around the longitudinal axis until, when coordinating the angle between the vertical axis of the gyroscope and the transverse axis of the object with the angle (90 ° + a), the relay enters into a symmetrical vibration mode and both ailerons start alternately
1 In the first samples (with ASG-30, see note on page 266.) the so-called omega-contacts were placed on ailerons. The introduction of the Ra relay made it possible to get rid of the "omega contacts" and the wires leading to them in the bearing planes.

deviate upward for half the period (1/20 sec.). In this case, the average effect of the ailerons is zero, and the acceleration due to the corresponding deviation of the elevator acts in the direction determined by the position of the control handle on the command sensor.
The remaining parts of the control system were similar to those shown in Fig. 85. In particular, the reset in this case was also carried out by pressing the reset button, due to which, initially, with the help of the relay pg, the gyroscope was disconnected and the ES reset electromagnet was switched on through the contact re. The contact rg simultaneously connected the negative bus to the ailerons control circuit, while the elevator control was switched on through the thermal deceleration relay TP only after about 1 second. This measure was supposed to prevent the possibility of a collision of a falling object, the engine of which was started through a sliding contact simultaneously with the ignition of the lighting device, with the plane if the “up” command from the command sensor would arrive prematurely. In accordance with this, the elevator was set to
Regarding the connection between the transmitting and receiving part of the control system, see Fig. 85, as well as 3.523.1. (The circuits closing through the 14-pole burst plug are shown in Fig. 86 and 91 in two concentric circles.)
A conductor was used as the receiving antenna, which was stretched from the left end of the horizontal stabilizer to the plexiglass insulated input located on the right side of the fuselage Hs-293 (Fig. 86 and 87). The AEG-230.6 antenna device was structurally

integrated with the input device and balanced from the outside.
Instead of the E-230 radio (Strasbourg), it was possible to use a receiver of control signals transmitted over a wired communication line, E-237 (Duisburg). The coils used to create a wireline link with an 18-mm steel wire 0.3 mm in diameter were fixed at the ends of the wings by means of pipes (Fig. 52 and 53), see 3.511.22.
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Both the Fritz-X bomb and the Hs-293 provided for heating of the instrumentation compartment with hot air. Air intake was controlled by a special indicator TR-2033 located on the carrier aircraft. A metal hose for supplying hot air was attached to the opening that closed with a spring cover in the tail section of the casing (Fig. 87).
The control equipment for the functional check of the radio control system was basically the same as for testing the FuG-203 (FuG-230a, see 3.523.1). For the control system over the wired communication line, FuG-207/237 were also prepared accordingly Modified control devices.
3.523.3. Other projects of the Henschel company. Hs-293 was the first of a number of developments of remote-controlled, propelled by jet engines flying projectiles, designed by Henschel. Serial samples of the Hs-293A were equipped with the FuG-2306 radio control system described in the previous section, while the Hs-2936 samples could have either the FuG-2306 or FuG-237 system.

Sample Hs-293c was designed for sheer drop; its main difference from the Hs-293A was the installation of a gyroscope measuring roll angles, with a large operating range relative to the transverse axis. Further it was planned to use a “control device” with rotating coils.
In order to be able to control over long distances using the target designation method (2.412.31) or to take the carrier aircraft after being dropped into the clouds, the Hs-293D [10] (Hs-296 [9]) bombs had to be equipped with a Tonne homing television head A ”(3.512.1).
Instead of the Walter 109-507 engine, the Hs-293H provided for the installation of a special engine (Schmid-ding 109-513) created by Henschel. With a lower total weight (100 kg, without a load of 48 kg), he had to create more traction (about 1000 kg for 10 seconds). Synthetic methanol (M-shtoff) and compressed oxygen were used as fuel [9]. Experiments were also carried out with a powder engine (WASAG 109-512) with a thrust of 1200 kg (Hs-293BG [9]).
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Glash 3
The company conducted experiments on the use of automatic fuses to ignite a warhead in the event that a direct hit was not achieved. In particular, the possibility of using fuses “Kakadu”, “Marabu” (3.514.21) and “Pistole” (3.514.22) was considered.
A modification of the Hs-293 planning bomb was the Hs-294 planning submersible bomb. It was controlled so that approximately 30–40 m from the target (ship), the bomb would enter the water at a slight angle and move there at a shallow depth (Fig. 2). After immersion in water, the wings and the tail part were separated and the bomb body moved rectilinearly further.
Since underwater approach the approach speed compared to flying in air was much lower, it was necessary, in addition to an impact fuse, to install a track counter (lag) or proximity fuse, which was supposed to detonate the bomb under the ship’s hull in the most vulnerable place.
Hs-294 did not leave the test stage. The same applies to the Hs-295 planning bomb, similar to the Hs-293, but with a larger caliber (weighing approximately 2000 kg).
The Hs-297 was designated as follows: the Schmetterling remote-controlled anti-aircraft missile in the design process; in production, she received the official encrypted designation “8-117” (Hs-117). The principle of its operation is considered below (3.525.11).
The Hs-298 was a remotely controlled fighter missile, see 3.524.2.
3.524. Remote-controlled fighter missiles (air-to-air missiles, or air-to-air missiles).
While the remote-controlled bombs discussed in the previous section were intended to destroy sea (1.312) or ground targets (1.311), by the end of the war, the German army had received jet weapons to combat air targets (1.313) for a very short time. These include, firstly, anti-aircraft missiles launched from the ground (3.525), and secondly, “fighter missiles” (rockets-
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air battle), launched from the side of the fighter. The German Air Force used unguided powder rockets, such as the 50-mm b4M rocket manufactured by the weapons plant in Lübeck. These shells were also used against ground targets, they were suspended under the wings of Me-109 and Me-262 fighters and launched from a distance of 1200-1500 m; In total, up to 48 shells were suspended under the wings of an airplane (11, 25).
Two projects of remote-controlled "fighter missiles" were also developed: X-4 and Hs-298 shells. Both shells passed successful tests in 1944-1945. The creation of the Hs-298 was completed in January 1945 (11, 25), and the X-4 shell was prepared for serial production, but the end of the war prevented the combat use of these promising weapons. It was also envisaged to use the Shmetter-Ling anti-aircraft shell from the aircraft (3.525.11).

It was supposed to use Me-109, FW-190 and Me-262 as carrier aircraft, as well as some new types of vehicles. The attack was carried out from the rear hemisphere, with a slight excess, if possible, in order to achieve greater speed and, together with it, greater projectile efficiency due to reduction. After launch from a distance of about 2 km to the target, the carrier aircraft should remain in the rear hemisphere of the attacked group; the pilot, in addition to controlling his fighter, which should have been equipped with automatic devices for the course, had to carry out remote control of the projectile flying in front of him using the optical covering method (2.412.11). In this regard, the control command sensor was placed in close proximity to the pilot.
3.524.1. X-4 fighter rocket. The design of the X-4 (serial designation “8-344”) was started in April 1944 at the Rurstal factory in Brakveda under the direction of Dr. M. Kramer after the preliminary work given by him at the German Research Aviation Institute. The missile has cruciform wings, a cruciform stabilizer with dual interceptors.
18 Telecontrol

Its main data, according to [9], are as follows:
Total length ................................. .. 2.10 m
The largest diameter of the hull ....................................... 22 see
Wingspan ............................................ .................. 86 cm
Sweep and width ......................... ..................... 28 cm
Width of the wings ....................... ........ 40.5 / 355, cm
Warhead
length .............................. ............................................ 45 cm
shell. ................................................ .................... Yu.il (steel)
weight of the explosive ................... ................. 20 kg
Coil housing
length............................................... ............................ 485 mm
diameter ................. ............................................... ...... 76 mm
total weight .................................... .................................. about 60 kg
Engine BMW 109-548 [9] LRE
weight without fuel ............................................... ......... 14 kg
total weight ................................. 22,5 kg
thrust ...................................... 140-b50 kg
duration of work .. ................................. 22 sec.
Fuel
“Tonka” (,, V-dam) ”- 50% crude xylidane
F + 50% triethylamine ......................... .... 1.8 kg
"Salbay" ("SV-shtof") - nitric acid ...... 6.7 kg
Initial speed ............ about 500 km / h rz 140
m / s
Airspeed ................ about 250 m / s
Range of action ............ about 2 km
Maximum flight range .. about 5 km

On average fuel tanks were placed in the compartment of the projectile (structural details, see [9]), and four wings were installed outside it, which were removed during transportation of the object. The combustion chamber with a central nozzle was connected to the middle part using three traction rods, which made it possible to adjust the direction of the axis of the nozzle.

The light metal sheath worn on this part at the back had a 7-pole discontinuous plug and a cross tail. It was attached to the nozzle using a special coupling.

An interceptor with an electromagnetic drive acting on both sides of the plane was mounted in each of the four planes of the stabilizer (Fig. 82). The tail section between the pull rods was used to place telecontrol units according to the
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wire communication line (2.312.24, 2.332.12 / .21): two T-relays, a position gyro with a switch and a 12-volt dry battery, fig. 92.

Fig. 91. Combat use of the X-4 fighter missile. 18 *



On two of the four wings, fairings of telecontrol wire coils were installed (Fig. 91 and 94). The other two wings carried lighting cartridges, used to determine the location of the object during its flight (2.412.11). The wings were installed not exactly along the axis of the hull, but with a slight transfer so that in flight the projectile would rotate around its longitudinal axis at a speed of about 60 rpm. This measure was of extreme importance, since possible deviations made during the manufacture and adjustment of the hull, wings or tail unit did not affect the accuracy of flight along the trajectory: due to the rotation of the projectile, the “average” trajectory (with symmetrical shifting of

the interceptors) remained rectilinear. According to the inventor, Dr. Cramer, thanks to this measure, the tolerances in the manufacture of shells were about ten times greater than (8.523.1) X-1 rocket stabilized relative to the longitudinal axis. The stabilizing effect of rotation increased due to an increase in the moment of inertia of the object around the longitudinal axis due to coils with wires located at a great distance from the axis (the full coil had 5500 m of insulated steel wire with a diameter of 0.2 mm).
The control of the interceptors was carried out in the same way as for Fritz-X: the edges disrupting the air flow alternately appeared on one or the other side of the plane, and the control action depended on the closure time in a certain direction (on the value of the control command K, Fig. 21). The frequency of the shift, however, the X-4 was higher: 20 Hz and, accordingly, T -? 0.05 sec (according to [9], 5 Hz?). But since the object was spinning, there could not be definite elevators and directions, both planes performed two control functions in turn. This was done by the control command distributor, which used a switch rotating by means of a positional gyroscope. The most simple control system corresponding to this is shown in Fig. 92. With this arrangement of the collector segments (4x90 °), the required value of the control action is reached only after 90 °. In order to achieve better
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approaching the control action to the required position specified by the command sensor, the collector was modified in accordance with the diagram in Fig. 93;

The brushes associated with the missile body
transmitter
8-5YU
-Yu
system uprapravleniya FuG 510 by plane - carrier
Yarivshaya
xi "---------- 12 * ± oash.A of Entitlement.
J '/ Y /' Lev- /? "W" YA

Cv?
'"(B 4 Axis, typified AV
Fig. 92. Schematic diagram of the X-4 projectile remote control system.
With this design (4x60 ° + 8x 15 °), the rudders' exact position was reached on average through 45 ° .
The principle of operation of such a DC control of a wireline communication system described in 3.511.23. The transmitting part of a wireline communication control system includes a sensor and a transmitter commands S-510, or ..D yusseldorf " (3.511.24),
0s, sta6ili-
ized
gyroscope
Brushes connected to the rocket body
and also the transducer fig. destabilized gyro-ac. The process in bulk is the X-4 projectile collector. preparation for action was, in
principle, the same as that of the FuG-203/230
(3.523.1) system.
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The main difference compared to the FuG-230 system was that in the X-4 the gyroscope, after its release and launch of the object, rotated without a drive (it worked on coast). Because of this, the need for installing a gyromotor converter in the X-4 rocket hull was eliminated.
Fig. 94. Remote-controlled “fighter rocket-” (aerial combat shell) X-4.
1 - jet engine; 2 - fuel tank for Salbaia; 3 - fuel tank for Tonka; 4 - cylinder with compressed air; 5 - valve; 6 - fuse (acoustic); 7 - wing; 8 - fairing coil; 9 - wire control line; 10 - lighting cartridge; 11? - gyroscope control system; 12 - battery.
In order for the shell to explode in the absence of a direct hit, the X-4 shell was equipped with an acoustic remote fuse (3.514.23), which was placed in the head of the object in a special shell with holes for the penetration of sound waves.
The X-4 ammunition among the remote-controlled weapons was supposed to have the simplest design. A lot of brilliant ideas were embodied in it. It is not possible to evaluate the “practical” effectiveness of the projectile, since it was not possible to use it in combat conditions.
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3.524.2. Hs-298 fighter rocket. The Hs-298 projectile was designed in 1944 by the Henschel aircraft manufacturing company under the guidance of Professor Wagner. It had a radio link control system, which in principle was similar to the FuG-230b system used in the Hs-293 projectile (3.523.2). The Colmar E-232 device (3.511.13) was to be used as a receiver, therefore the receiving part of the control system was designated FuG-232. The airplane transmitting part of the control system with the Kel transmitter was called FuG-206. The transition to the Kogge UHF radio control system was envisaged (3.511.14).
To supply electric current to the on-board system, a generator driven by chickenpox should have been used instead of conventional batteries used so far. The Hs-298

projectile had flat swept wings with ailerons, the tail unit had a horizontal stabilizer of 1290 cm2 with fixed end washers and elevator.
The main data of the projectile are as follows [9]:
Total length ................................ 2,30 m
Maximum height fuselage .............. 41 cm The
maximum width of the fuselage .............. 20 cm
Wingspan .......... ................... 1,30 m
Wings ....................... ...... 51 / 23.5 cm
total weight .................................. 295 kg [25]
The Schmidding RD powder propellant engine 109-543 (installed in the fairing under the fuselage)
length .................................. .. 81 cm
diameter ..................................... 17.8 cm
weight without fuel .............................. 63 kg
starting weight ............. .................. 95 kg
starting thrust of
about 150 kg for
5 seconds.
draft in 20 seconds ...........
Fuel (solid) ...........
Initial (starting) speed of
about 50 kg diglycol-dinitrite about 500 km / h 140
m / s
maximum ................
Range ..........
Maximum flight range of
about 235 m / s
1.5 + 2 km about 5 km
The Hs-298 projectile also had to be equipped with an automatic fuse, and in the first place
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provided for the installation of the Kakadu proximity fuse operating on the decimeter range
(3.514.21).
Hs-117 can also be attributed to “fighter missiles,” since this projectile had to be adapted for launch from an aircraft, although its main purpose was anti-aircraft fire (3.525.11). Experiments were also conducted with the planning bomb Hs-253 (3.523.2) in order to use it against groups of aircraft (launch from a fighter bomber). In this regard, it should have been equipped with either a proximity fuse or a device for detonating a warhead at a distance: receiver E-230h (3.514.1). For a similar purpose, the FuG-206 / FuG-232 radio control system (for Hs-298 see above) had an explosive ignition device at a distance through the fifth low-frequency channel. The application of this method also allowed the use of Kogge type decimetric fuses (3.511.14).

3.525. Remote-controlled anti-aircraft shells. The wider the hostilities unfolded, the more serious the work was carried out in Germany to create effective means of struggle against large groups of enemy bombers, which undermined the country's military power with impunity. These works went, on the one hand, along the lines of creating the “fighter missiles” described in the previous section, which were really developed only from 1944, and on the other, along the lines of creating a number of missile projectiles that were supposed to replace anti-aircraft artillery shells and which in terms of caliber, range and accuracy should have significantly exceeded the latter. Initially, there were several types of non-guided, or self-guided, anti-aircraft missiles, such as the Typhoon projectile (length 190 cm, diameter 10 cm, launch weight 47 kg) with a rocket engine, which was supposed to be launched in volleys and reach a height of 15 km at maximum speeds of 760 m / s [9]; further developed by Rheinmetall-Borzig in collaboration with the Goering Research Institute, Braunschweig-Volkenrode, Hecht missiles

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weighing 140 kg and Vöerlie (F-25-120 kg and F-55-470 kg ) [9, 25].

The actual telecontrolled missile defense systems were mainly subsonic anti-aircraft shells "Schmetterling" and "Entzian"; supersonic anti-aircraft shells “Wasserfall” and “Reintohter”.

Of all the developments of the beginning of 1945, the most promising Schmetterling and Wasserfall shells, as well as the X-4 fighter missile, were accepted for further development [11]. However, not one of them was tested in combat conditions before the surrender of Germany.

As regards equipping anti-aircraft shells with telecontrol technology, it is necessary to point to the specially developed Rhineland system, which will be discussed below (3.525.2). Now it is necessary to compare the characteristics of the four named anti-aircraft missiles (mainly according to [9], see also Table 15).

Fig. 95. An experimental sample of the Schmetterling anti-aircraft missile.

3.525.1. Anti-aircraft shells.

3.525.11. Schmetterling Hs-117. Produced by Henschel aircraft manufacturing plants, Schönefeld, Ber-

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Lin (Prof. Wagner). The projectile in the middle part has flat swept wings with ailerons (length 33 cm). Plumage: fixed vertical stabilizer, horizontal stabilizer (1 m span) with elevator (in two parts).

The main data of the projectile:

Type designation .......................... 8–117

Total length ........... ..................... 4.0 m

Case diameter ..................... ....... about 38 cm

Wingspan .............................. 2.80 m

The width of the wings. ............................ 66–32 cm

total weight .............. ................... about 450 kg The

weight of the warhead ....................... ... 23 4-40 kg

Start .............................. from an inclined installation

Starting engines: 2 starting Schmidding accelerators 109–553 (resettable)

length .................................. 2.40 m

diameter .................................. 16.8 cm

weight .... .................................. 85 kg

diglycol fuel .......... ............ 40 kg

thrust ........................... 1750 kg each

burning time. ................. about 4 sec.

The nozzle axis is directed at an angle of 30 ° to the longitudinal axis.

The main engine of the BMW 109–558 LRE (or Walter 109—729 LRE) is installed in the rear of the projectile body; nozzle with a central location:

length .................................... 2.70 m
diameter .. ................................ 35 cm
weight without fuel ........................... 84 kg
total weight ................ ................ 158 kg
traction .............................. ....... 380-60 kg
operation time ................ 33-b70 sec.
Fuel
“Tonka” (“R-dam”) 1 ...................... 12.7 kg
“Salbay” (“SV-dam”) 1. ................... 59 kg of
Walter 109—729 rocket engines with fuel: 30 kg of kerosene + 68 kg Salbay
Flight speed of about 75 - = - 300 m! Sec ( Ma-0.23-0.9)
Ceiling (maximum) .................. about 15 km
(practical) ........... ........ about 10.5 km
Range (with a warhead weight of
23 kg) .......................... ..... 32 km (maximum)

The fuselage and wings were made of light metal. The warhead was asymmetrically filled: on one side there was a military charge with a fuse, and on the one side, see page 274.

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other — an onboard electric voltage generator driven by a propeller. Hs-293 bomb telecontrol system (3.523.2); As a receiver, Colmar was used (3.511.13). The crossover frequencies for the ailerons and elevators were different (25 and 5 Hz, respectively). The steering wheel was driven by electromagnets of a control device with rotating coils.

To facilitate the launch, the lower launch rocket ignited somewhat earlier than the upper; after fuel burnout (after about 4 seconds), both launch rockets were discarded.

Upon reaching the set speed, the regulator of the number Ma had to keep it constant, acting on the fuel supply (depending on the pressure head). In addition to being used as an anti-aircraft projectile with launch from the ground, the Hs-117 was tested on an airplane as an air combat projectile (3.524.2).
3.525.12. “Enzian” - a projectile with highly located wings (sweep 30 ° C), with one pair of rudders, tail unit - stationary horizontal stabilizer. Designed by the Upper Bavarian Research Institute in Ober-Ammergau (Dr. Konrad) and the Goltsbau company in Sonthofen. Basic data:
Type range ................................. E-1 to E-5
Data of type E- 4
Total length ................................. 9.65 m
Largest diameter ....... .................. 2.22 m
Wingspan .............................. 10 m
The total area of the bearing surfaces ......... 21, 57 m *
Starting weight ................................ 1963 kg
Start ......... ...................... from an inclined installation
Starting engines: 4 starting Schmid-ding missiles 109–553, discharged (see “Schmetter-ling”)
Main engine (three options are possible):
(Walter turbojet rocket engine) Konrad liquid propellant rocket engine (for two-component
fuel)
(E-1 ... 3) E-4
E-5
weight without fuel full weight thrust
operating time
96 kg about 700 kg 2 -1 ton 70 sec.
2.5-1.5 t 56 sec.
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Fuel
115 kg Visol 230 kg of gasoline +485 kg “Sal- (“ Vg-shtof ”) +320 buy" + kg "Salbay"
Airspeed
...
Ceiling ..........
Range
("sv = shtof ”) about 250m / s (Mara 0.77)
.............. 13.5" l *
.............. 40 km
The external form of the Enzian shell is borrowed from the Messerschmitt manned fighter, Me-163. Despite its large size, the design of the projectile was amazingly simple: the projection glider had to be made of wood. For control in the polar coordinate system, only two steering planes were used, which were located on the trailing edges of the wings: in the differential movement they acted as ailerons (control relative to the longitudinal axis), while moving in the same direction up or down - as the elevator (control around transverse axis). Four launch missiles in 4 sec. Combustion with a total thrust of 7000 kg were supposed to tell the rocket a speed of up to 900 km / h and then (simultaneously with the main engine), separated from the projectile.
3.525.13, “Wasserfall” - a projectile with four cruciform wings of small size, tail feathers - 4 stabilizers with large aerodynamic rudders.
Developed by the Peenemuende Anti-aircraft Testing Ground in collaboration with the Peenemuende-Ost Army Research Institute or the Karlshagen Electromechanical Plant.

Basic data:
Total length ................................ 6 m
Largest diameter ....... .................... 70 cm
Start ... vertical, free, stabilization with 4 gas rudders Engine ... LRE with a centrally located nozzle. Thrust ......................... maximum 8 t
. Wingspan .. Width of wings. Starting weight
Empty weight .......
Combat charge weight
......... 1.92 m
.......... 2.15-1.07 m
• .. about 3600 kg (!) About 1600 kg ....... .. 100 laid down (!)
Duration of work
41. sec.
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Fuel:
450 kg Vizol + 1500 kg Salbay (to ensure fuel supply of 65 kg of compressed nitrogen at a pressure of 200 atm)
Maximum flight speed .............. ... about 600
m / s (~ 2.2 Ma)
Rise time before changing the angle ............. about 6 seconds
Achieving the speed of sound .......... ......... after about 20 seconds.The
ceiling .................................. ... IOv-18 km Range
.............................. 32 26 km according to
[9] or [11 ]
The Wasserfall projectile, like other long-range missiles (cf. A-4b and A-9, which also had small wings, 3.522), was created in Peenemuende. The gas rudders needed to stabilize the “free” start were connected to the four aerodynamic rudders so that they were actuated as a whole. Due to the combined action of the rudders of both types in the range of speeds and heights favorable for control, the shells reached transverse accelerations up to 12 d [25]. Until the end of the war, about 50 experimental shells were fired [9].
3.525.14. Reintohter is a two-stage rocket. Developed by the companies Rheinmetall-Borzig (Berlin) and Leba (Pomerania). Developing options for R-1 hR-3.
Option R-1 Length
Body Diameter Wings 4
Span
Wing width Steering wheels
Starting weight R-1 R-3
Weight of warhead Start
Engine (R-1) Number of nozzles Thrust (maximum)
First stage 2.15 m 51 cm swept wings
4.4 m 82.5-30 cm
Second stage 3.60 m 50 cm
6 swept wings 2.65 m 71-25 cm Steering planes 40 X 35 cm (front)
750 kg 1000 kg
2x2.20 kg 536 kg
- 23 kg
From an inclined launcher Powder rocket 7 6
7.5 t \ 0.6 sec. 16 t; 2.5 sec
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Fuel Diglycol — dinitrate bombs
Fuel weight 240 kg 220 kg
Engine (R-3) 2 powder rockets rocket engine, Konrad “
Thrust Maxim. 14 t; 0.9 sec 2.18-N, 8 t.
Duration of work? 15 + 38 sec.
Fuel 2x250 kg diglycol 88kg Vizol +
-f 335 kg Sal-Bai
Maximum flight speed (Mat 1.5)
Ceiling (when starting at an angle of 70 °) (according to [9]?)
Range of about 40 km
The Reintohter missile was the only remote-controlled projectile with control planes located in the head of the object (like a duck, see fig. 96). The rudders were driven by electric motors, and the regulation was carried out in a closed system (feedback link is a potentiometer, see Hs-293 elevator drive, Fig. 90). The stabilizers were made of wood; metal edging of the planes was used as a receiving antenna for the radio control system. Relative to the longitudinal axis, the rocket was stabilized using a gyroscope; this was carried out by moving the control surfaces in opposite directions.
3.525.2. The program "Reinlan d". For remote control of anti-aircraft missiles in 1944, under the guidance of Telefunken (Berlin), a unified program was developed to create a system of several installations covering the whole range of remote control tasks: determining the location of an object and target, controlling and igniting an explosive. This Rheinland program (47, 114) was supposed, on the one hand, to ensure the creation of a single radio equipment for the ground battery of guided anti-aircraft missiles (Grüne Wiese [15]) and, on the other hand, to create as simple a flight system as possible ( Sönlein, see below), suitable for various types of anti-aircraft missiles (3.525.1).
3.525.21. The general scheme. In order to ensure successful (leading to the defeat of the target) telecontrol of anti-aircraft rocket-rockets-shells it is necessary to solve the following tasks:
Fig. 96. Reintohter (B-1) two-stage anti-aircraft missile missile
at an exhibition in Anglin.
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1. Determining the location of the target) / 94P.
2. determining the location of the projectile) '' ''
3. controlling the flight of the projectile (2.3);
4. ignition of a warhead (2.6).
According to what was stated in 2.41, it initially seemed that the guiding beam method (2.32) was the most suitable for controlling anti-aircraft shells, since there was no need for a separate location of the object (2.412.13 and Fig. 30) and the solution of problems 1 and 3 completely carried out by tracking the target from the ground [9]. But since in the last years of the war the tasks of creating the necessary technical devices have not yet been completely solved, especially for obtaining sufficient accuracy of the guiding beam and for regulating the position of the governing bodies using a beam detector for determining the deviation of the projectile from the beam in two coordinates, the Rheinland program Separate determination of the target and missile locations by the covering method (2.412.1) and telecommand control
(2.31) were provided for .
In addition, it was envisaged to use the homing method (2.412.31) by means of television heads (“Tonné A”, “Sprotte”, see 3.512) in shells (primarily “Wasserfall”) or the transition to homing (2.412.4, 2.5, 2.75, 2.76) after the launch of the rocket with the help of telecommands in close proximity to the target (about 1-g-3 km). However,

the Rhine-Land system itself did not have this equipment (3.513).
In order to ignite the explosive in the anti-aircraft shells, proximity detonators (2.632) and, first of all, the high-frequency Kakadu and Marabu fuses (3.514.21) were to be installed. As a possible subsequent solution, the ignition command should have been issued from the ground after comparing the distances measured electrically to the target and the object (2.612, 3.514.1).
The principle of positioning and projectile control according to the Rhineland method is shown in Fig. 97.
The block diagram of the system corresponds to the circuit depicted in Fig. 29. The location of the target is determined using the
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using a radio meter and a CMC body device: the axis of the antenna is sent to an airplane (or a group of aircraft), which should be hit. The directional receiving antenna of the projectile positioning device is pointing (by hand, automatically or due to hard communication) in the same direction and direction finding the radiation of the radio transmitter installed on the guided projectile, creating a signal as a light spot on the screen Control command
transmitter
Command receiver Jy * h * Sensor

teams
) Radioizmeritetny sight
Fig. 97. The principle of operation of the anti-aircraft missile remote control system according to the Rheinland method.
Tubes. Deviation of the spot from the central crosshair is a measure of the angle of deviation of the projectile relative to the target (the so-called radio-measuring sight). The operator’s next task is to: move the handle of the DC command sensor to hold the light spot on the central crosshairs, and thereby the projectile on the registration line. Control commands are transmitted through the command transmitter PKU;

19 Remote control
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on board the projectile by the command receiver and act on the governing bodies. A directional optical system can be connected to the antenna system of the target positioning device, which would make it possible to visually control the rocket, combining the projectile illuminator visible in the optical system with a crosshair (Rheinland oV). The operator's seat with this control method moves with the antenna device of the radio measuring system.
The control methods (2.411.2) differed depending on the nature of the projectile launch (1.334.1, 3.525.1 and Table 15). For rockets launched obliquely from a carriage (launcher) (Schmetterling, Enzian, Rein-Tochter), the carriages themselves should, if possible, be controlled in horizontal and vertical planes using a radio measuring system. This required a parallax metering device, due to the necessary distance between the launch site and the radio measuring system (FuMG), and a lead metering device, since during the launch the direction of projectile movement should not change and anti-aircraft shells should have final acceleration. In order to carry out a reliable capture of the object immediately after the start, the device for determining the location of the projectile must be made so that
For shells with a vertical launch (Wasserfall), the method should have been somewhat different. At first, the antenna device of the direction finding system was sent not to the target, but to the projectile standing on the launch pad. After the start, the antenna device, thanks to the computer of deciding the entry into the control mode, automatically moved in the direction of the target, the position of which was determined by the radio measuring system. The projectile followed the movement of the antenna due to the fact that the operator using the visor converted deviations into control commands. After the end of entering the control mode, the process proceeded in the same way as with an inclined start [47].
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3.525.22. Installations and devices. The Rhine-Land program provided for the creation of three systems, A, B and C, not counting the preliminary Rheinland oV system, see table. 15. The first stage of the program - the Rheinland A system - mainly consisted of the Alsace ground system and the Sönlein onboard system.
A. The Alsace ground system had:
1. To determine the location of the target — a two-axis direction finder with a huge (7 m) Rize reflector (with a directional optical system) and a device — an indicator of the deviations of the antenna axis from the direction to the Mannheim target.
2. To determine the location of the projectile - a two-axis direction finding device "Reingold A", consisting of a directional antenna (3 m) "Mannheim" with a command issuing point related to it.
The Mannheim radio meters were replaced with a 50-cm direction finding receiver with a radio sighting device (see above). In addition, there were low-frequency devices for issuing commands (included between the command sensor and the modulation input of the command transmitter).
3. To control the projectile - the Kelheim device, consisting of a Kael transmitter (S-203, see 3.511.12) and a rotating polarized ultrashort-wave antenna (cruciform dipole). To transmit the commands, the Kel – Strasbourg method was used with the modified low-frequency part as described in section 3.511.13 ("switching without phase jump", see Fig. 51).
4. For an inclined or vertical start - a calculating and solving device for accounting for parallax and calculating the lead angle or a calculating and solving device for entering the control mode of the company "Gyroscopic devices", Berlin-Zelendorf.
B. On-board system "Sönlein A" had:
1. To determine the location of the projectile - a transmitter "Ruse" of a 50-cm range

of low power with a wedge-shaped dielectric emitter (radiation in the direction of the rear hemisphere).
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Table 16
DEVELOPMENT OF “RHEINLAND” SYSTEMS
^ -—______ ^ nstems ^^ ,, Rhineland 6V ’“ Rheinland A ’“ Rheinland B ’“ Rheinland C '* Direction
finding system 2-axis 2-axis Z-axis
OMR and OMC OMR Optical Isolated General
Wavelength range Decimeter Decimeter Centimeter
OMR Direction Finder Optical “Reingold A” “Reingold B Combined with Marbach”
OMC Radio System “Würzburg – Mangey m” “Mannheim-Riese“ Computing and Solving Devices ““ Parallax accounting, prediction calculation (+ entering the mode control)
Command transmitter “Kelheim” “Kai” “Kelheim” “Kahn” “Crane”
Ground system “Burgund” “Franken” “Alsace” “Brabant” “Hansa”
Transmission of commands VHF UHF UHF Decimetric (“Kogge”)
On-board system “ Strasbourg ’“ Colmar ’“ Brig ’“ Sönlein A ’“ Sönlä Mr. B "," C Zonlyayn "
Listener" Strasbourg "" Colmar "" Brig "" Marburg "" Brig "" Frigate "
transmitter location" Rize "(decimeter) centimeter vy
Kakadu, Marabu proximity fuse (or others)
Note: CMC - target location; OMP - locating a rocket.

2. To receive control commands, use the Strasbourg ultra-shortwave receiver or the modified Marburg (3.511.13), and the Colmar receiver for the Schmetterling projectile.
3. For ignition of an explosive, one of the sensitive remote fuses or proximity fuses under development, primarily the Kakadu or Marabu (3.514.21).
The on-board systems on various missiles varied depending on the power supply, regulatory requirements, etc., and in accordance with this they bore various additional designations, for example, "Sönlein A – S" for the projectile "Schmetterling" - E for the projectile "Enzian" —W etc. (3.525.1).
The transition from the Rheinland A system to the Rhine-Land B system consisted mainly of replacing the Kel – Marburg ultrashort-wave telecontrol system with Kogge decimeter equipment (3.511.14). This replacement should have provided the following benefits.
1. Greater noise immunity due to the improvement of receiving antennas (2.72, 2.73); as wires in the field of VHF, some wires or insulated parts of the design of shells were used, while for devices of the decimeter range, the installation of dielectric wedges with directional characteristics was provided.
2. Reducing the size of the on-board system due to a decrease in the number of lamps in the receivers: "Strasbourg" (12 lamps), "Brig" (4 lamps), "Sönlein A" (15 lamps), "Sönlein B" (7 lamps).
3. The Brabant ground system, compared to the Alsace system, was also simpler in the sense that in the second there was no separate ultrashort-wave transmitter (Kelheim). The "Kai" or "Crane" decimeter transmitter (3.511.14) were the components of the Reingold B direction finding device, on which the transmitting antenna was mounted, with which it was aimed at the target. The number of lamps in the Alsace and Brabant systems was the same: 222 lamps (!) [47]. Devices for determining the location of targets and missiles of the latest modification

"Rhineland S" had to be made triaxial and integrated into the Hansa system. This was made possible thanks to the introduction of a centimeter-wave radio measuring system (Marbach) [15], which, with the same or better accuracy, made it possible to confine ourselves to 3-meter reflectors, as a result of which the whole system could be fully motorized.
In March-April 1945, the first Grüne Wiese system was supposed to be installed in Harz - an experimental battery with the Alsace ground system and Schmetterling anti-aircraft shells equipped with the Zenlin A-S airborne system, but the American occupation prevented the creation of this batteries.
3.526. Other developments. In this section, it is necessary to consider several more types of remote-controlled weapons, about which the author cannot provide as much information as was given in the description of previous samples (3.51 and 3.523, 3.524, 3.525), since he had no direct relation to their development, and also, he did not have the necessary materials (as per 3.522).
3.526.1. Ground objects. Along with V-2, the Goliath tracked torpedo and the B-4 explosive carrier gained wide popularity during the Second World War.
3.526.11. Caterpillar torpedo "Goliath". The torpedo was a miniature tank equipped with explosives; it was controlled by the method of individual commands (2.311.21) over the wires (2.332.12). In this case, various commands for controlling and exciting other processes (2.612), such as "explosion", corresponded to various DC pulses (2,332.21) [46]. The control system provided for locking, which allowed changing the sequence of pulses (see 3.511.21).
3.526.12. The explosive carrier "B-4" ("G-Schlepper") acted on the same principle as

the “Goliath”. While Goliath, from the point of view of classification given in Section 1.2, was a “carrier of action” (1.221.1), B-4 was a returnable carrier for a “carrier of action”, that is, a combat charge

(1.221.2). We are talking about a remote-controlled armored tracked vehicle, which could be given the following separate commands on the radio (2.331.11) (2.311.21, 2.612): forward movement, stop, rearward movement, right turn, left turn, staging of the smoke curtain in several bands charge reset, self-explosion. To transmit control commands and special commands, the FKL-8 system described in section 3.511.11 was used. The FuKE-8 receiver was located in a telecontrolled facility, while the FuKS-8 transmitter with the KoG-2 command sensor included in the kit (Fig. 43) was located at the mobile command post, which was in visual communication with “B-4” (2.412 .eleven). If direct observation was not possible, then the issuing of commands could be carried out according to the instructions of a specialist observer (see note, p. 66). (2.412.31), for which the controlled object was to be equipped with a television camera (“Tonné R”, 3.512.1) and an ultra-short-wave transmitter [48].

3.526.2. Managed ships.
3.526.21. Target ships. As already mentioned in Section 3.1, from the very beginning of the development of communication technology, numerous experiments were conducted on the remote control of ships. These experiments led to the creation of the Zeringen and Hessen target-controlled radio target ships in the German Navy in the 1920s. The technique of the method used in this case (multiple teams divided by time, see 2.311.21) was described by G. Schuchmann, Siemens and Halske, Berlin1.
The Tseringen ship was controlled using a simple ten-day command system, in which impulses were issued in accordance with the desired command number. Then there was a pause, fixed by means of a relay, and, finally, additional impulses were issued up to the number 10. As a criterion for the correctness of the transmitted command, a temporary relay for pause
1 was triggered. a request to Shukhman, who reported the information given in the text.
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and the correctness of additional pulses up to 10. Each signal received at Tseringen was transmitted back to the control vessel, where it was automatically compared with the transmitted signal.
The later target ship Hessen used a binary command system similar to the one used for squeaking telegraphs.
For reasons of reliability, double pulses were issued. In the indicated binary system, a double pulse “H--” corresponded to a positive pulse,
and a double pulse “- +” corresponded to a negative pulse. The receiving device then monitored whether the combination “+ -” or “- +” arrived. If there was no combination, then the “interference command” followed from the receiving
side. Feedback and control were then used in the same way as in the ten-day management system at Zeringen.
3.526.22. Speedboats. As in World War I with the primitive means of technology of the time
(3.1), so in the last war, various types of remote-controlled ships were designed, which were to be controlled using radio and wire communication lines from the ground, from another ship, or from an airplane. One of these projects was Tasso [46], for which the Kel – Strasbourg system was to be applied (2.312.24, 3.511.12). Details to the author are not known.
3.526.23. Torpedoes. The main difficulty in the implementation of telecontrol of torpedoes (generally underwater objects, 1.312.2) is that electromagnetic waves in the aquatic environment are extremely weak. The only NY project in this area that used electromagnetic waves with a frequency of about 100 kHz (3.511.15) was not completed. Another development was the NYK wire management system (see 3.511.25). In this connection it is necessary to mention the combined control method according to Kroki, see 2.333.
The location of a torpedo controlled by the telecommand (2.31) method was to be carried out exclusively visually, due to which its trajectory was also visible to the attacked enemy (along the trail of gas bubbles or with an electric drive, by spots Examples of completed and engineered
paint systems 297 along a path). It was also planned to install a lighting lamp in the rear part of the torpedo, which was supposed to remain invisible from the front hemisphere. It could be seen only from above at sufficiently large angles (therefore, when controlled from an airplane), while at small viewing angles, there was a complete reflection in the water.
In addition, a wire control from a submarine was designed according to the target designation method (2.412.32): the Lerche direction finding head (3.513.34).
For automatic homing of torpedoes, the heads of “Tsaunkënig” (3.513.34) or “Gai-er”

(3.513.35) should have been used, of which the first (passive device) could be used in combat conditions [14].
3.526.24. The launch of rockets from the water. It is necessary to mention the project, which was supposed to allow the launch of rockets from under the water. The method of such a launch was developed in connection with submarines, which were supposed to carry or tow missiles, as well as have the appropriate equipment.
After in Peenemuende already in 1942, an experiment was successfully conducted to launch a powder rocket from a submerged submarine, in 1943-1944. Studies began on the possibility of launching A-4 missiles from floating launchers, which were supposed to be towed by submarines to the firing site [11].
3.526.3. Aerial objects. The telecontrolled objects described in sections 3.521–3.525 can be called the most important German developments, which either were already used in combat conditions (V-1, V-2, Fritz-X, Hs-293), or were intensively prepared for mass production at the end war (fighter and anti-aircraft missiles). In these sections, several projects were also called that, in the process of their development, were closely connected with the above types of weapons (A-1 to A-10, X-5, Hs-294, Hs-295, Hecht, Foyerlilia) . Here, some more projects should be mentioned, which, in addition to those already considered, were developed during the war in Germany. These projects concern bombs of various types.

3.526.31. Falling bombs. In addition to a series of “X” type shells with interceptor control, designed at the Aviation Research Institute (3.523.1), there was also a project for the FB-10Q0 bomb, the control system of which was developed by Siemens and Halske. This telecontrolled falling 1000-kilogram bomb had a cylindrical tail unit through which control was carried out in the Cartesian coordinate system relative to the transverse and vertical axes using continuously changing values of control commands. Development was discontinued around 1943 when it became clear that the SD 1400-X shooting bomb, which was simpler in design, gave better results.
3.526.32. Planning bombs. After various studies have shown that uncontrolled planning bombs to ensure a given flight path do not require precision production, in 1940 the aircraft manufacturer Blom and Fos, Hamburg-Finkenwerder (regardless of the creation of remote-controlled planning bombs at Henschel aircraft plants, 3.523.2, 3.523.3), the development of the BV-143 self-guided gliding bomb was started. This projectile with a length of about 6 m with a total weight of about 1 tonne had a 500-pound armor-piercing bomb (SB-500) and a Walter jet engine (operating time 1 min.). The projectile was dropped from the aircraft and developed a speed of about 200 m / s in the planning flight. It was equipped with an automatic control system with respect to three axes (2.23),
Bomb BV-143 was intended primarily for hitting naval targets with the expectation of hitting a few meters above the waterline. Upon reaching a certain flight altitude, control around the transverse axis was carried out using a “high-altitude probe”, which, due to the impact on the landing flaps, was to remove the object from the planning flight and then stabilize it in horizontal flight above the water surface (2.223).

Along with the use of mechanical probes, experiments were conducted with capacitive and optical measuring instruments of small heights. Management problems were mainly dealt with by the research institute of AEG. To control the vertical axis, in addition to automatic stabilization, radio control was provided according to the principle of the Kel-Strasbourg system (3.511.12, projectile BV-143B). After lengthy tests and structural changes of this “surface torpedo” (see Fig. 2) did not lead to overcoming the difficulties associated with aerodynamics and control, the BV-143 shell was removed from further tests in 1944 [25].
The next development of the aircraft company. “Blom and Foz” was the planning long-range bomb BV-246, which was planned in 1943. It had a very small planning angle (1:26) and was intended as a means of defeating area targets; when dropped at an altitude of 8000 m, the range of the bomb reached 200 km. It was also equipped with an automatic control system in three axes. It was also planned to equip the BV-246 with a homing device operating on the basis of infrared radiation (2.552.12, 3.513.2), with the aim of using it to destroy small targets, such as factories, metallurgical plants, and ship clusters. But since the German command in relation to the air war in 1944 was supposed to think more about defense than about attack, at the beginning of the year work on the creation of the BV-246 was stopped, however, by the end of that year they were resumed: on the basis of a planning bomb, a flying target for anti-aircraft missiles was created. In this regard, a device was installed at the facility that provides software control of the turn (2.251). By that time, when it was possible to achieve a perfect turn-around flight simulating the flight path of a bombers ’connection, the Grüne Wiese system ceased to exist, see 3.525.2 [25].
Autonomously controlled glide bombs 200 GB-odnogiroskopnoy stabilization with respect to the vertical and the longitudinal axis of M. Mayer, was

manufactured by "Rheinmetall-Borsig"; its development was discontinued in 1942 in favor of remote-controlled bombs [25].
3.526.33. Rockets. In addition to those already described, another shell deserves attention, which was supposed to appear shortly before the end of the war as a modification of the X-4 fighter rocket (3.524.1). We are talking about the X-7 - the smallest remote-controlled projectile. This projectile, with a starting weight of 9 kg, was supposed to reach a speed of about 100 m / s using a WASAG two-stage powder rocket engine.
The range of the projectile reached 3 km. This 76 cm long projectile was supposed to be launched from the ground against tanks and attack aircraft. The telecontrol system was similar to the Düsseldorf wire control system (X-4) (3.511.24, 3.524.1, Fig. 94) * Unlike the X-4, the X-7 rocket had to have only a pair of stabilizing planes with interceptors.

3.526.34. Air targets. Mentioned above
(3.526.32) that at the end of the war there were attempts to use the BV-246 glide bomb from the aircraft as a target for training firing (1.212.3) with remote-controlled anti-aircraft missiles. In 1940-1941, the company Argus Motor, Berlin, built a small target plane (1.211.3) for training firing of anti-aircraft artillery. It was equipped with a propeller engine, took off and landed at a regular airfield. For remote control purposes, a special receiver was installed in the cylindrical fuselage of the aircraft, which, by means of electromagnets, actuated the rudder planes. The receiver, created by Lorenz AG (Berlin-Tempelhof), worked like the Strasbourg receiver (3.511.12), but was made in the form of a long cylinder with a diameter of about 8 cm. The Kel II transmission system (FuG was used on the ground) -204), which consisted of the S-203 transmitter, the MT-204 modulation part, and the Ge-204 command sensor (similar to the Ge-203 sensor, 3.511.12); a half-wave horizontal dipole mounted on a tubular mast was used as a transmitting antenna. In addition to continuous control commands (2.312.24),
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could transmit individual commands (2.311.1) to turn off the ignition of an internal combustion engine. Landing of the target aircraft was carried out in a controlled planning flight.
3.526.35. Aircraft. Section 3.1 has already mentioned the creation by Siemens of a complete tele-control system for a Ju-52 three-engine aircraft. It is also necessary to point out here developed by the company E. in 1944 Bachem ”Nutter BP-20 manned interceptor for vertical launch from a launcher. At launch, and to a height of about 1000 m, the projectile had to be controlled automatically using aerodynamic and gas rudders [9, 10, 105, 106].
Finally, we present another project that was developed in the last months of the war by the German Air Force command: the use of a special aircraft loaded with explosives against important ground targets, such as clusters of ships or enemy bombers. The Mistel combat charge aircraft was supposed to fly to the target using its own engines and at the same time carry a small Gukkepak fighter aircraft, see Fig. 100 [12].
Upon reaching the target area, a fighter plane (for example, FW-190) was separated from the carrier aircraft (for example, Ju-88), equipped with a warhead, and the latter was aimed at the target by a fighter pilot who was now flying on his engine. For remote control, the fighter was equipped with an on-board radio transmitting system FuG-206 (3.524.2), and the carrier aircraft was equipped with the Strasbourg N receiver (3.514.1). It was also planned to equip the carrier aircraft with homing devices (3.513) and proximity fuses (3.514.2).
These are the German projects of telecontrolled objects.
In conclusion, it is necessary to mention one American project, which in this connection deserves attention, since it, on the one hand, was based on German works, and on the other hand, it can be used to show the level reached by the automatic control technique (according to 2.1, it can be considered as a preliminary stage of telecontrol technology) after the war.
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3.6. TRANSATLANTIC FLIGHT WITH FULLY AUTOMATED CONTROL
An example of the most complete application of the automatic control technique [65, 66] is the well-known fact of the transatlantic flight of the US Air Force C-54 transport aircraft carried out in 1947. During this flight on the Garmon Field (Stephensville, New Foundland) - Bryza (Norton,
Fig. 98. "Mistel" - "Gukepack" ("Father and Son").
England) with a length of 3800 km, all control was carried out by fully automated electromechanical devices, although there was a crew on board that did not interfere with aircraft control from start to landing. 10 hours 15 minutes of flight control

devices on the aircraft were used repeatedly and in different order, as can be seen from table 17.
The control process was divided into 13 separate stages, which were sequentially switched on one after another through a special switch. The subsequent operation of the switch occurred under the influence of various devices shown in column 13. The individual phases of the flight partially represented a flight with purely autonomous control, according to the definition given in 2.11, 2.21,2.22,2.23 and 2.24 (flight phases

1 ... 5, 7, 10), and partly a flight to a beacon in the sense of the definition given in 2.13 and 2.254-2.5 (flight phases 6, 8, 9, 11, 12). Switching between phases 6–7, 8–9, 10–11, 11–12 was caused by special contacts (“Fiihler”) of the beacon, blind flight, or planning receivers, which were triggered when the beacon passed or, respectively, when entering the zone of the landing system . Stabilization around the longitudinal axis (2.23) during the entire flight was carried out by the transverse channel of the autopilot. The pilot took control after landing, that is, during the run; in principle, this process can also be carried out by autonomous control and telecontrol methods, as was the case, for example, with the well-known Siemens-Geschann system Ju-52, which was already tested in 1940 (3.1).

At a conference on aeronautical radio navigation held on April 17, 1953 in Frankfurt, it was reported that in the aircraft control system during the transatlantic flight, an airway meter and autopilot built on the basis of the air lag of the V-1 projectile were used based on an automatic control system with respect to three axes of the LGW type [66]. Meanwhile, in the United States, intensive work continued in this area, the purpose of which was to increase flight safety.

The prospect of the peaceful application of automatic control and telecontrol technology is already looming. Today, all transport aviation for long-distance flights relies on this technique. Perhaps tomorrow it will appear on our freeways in order to drive vehicles from a distance and thereby contribute to improving its traffic safety. Theoretical development of these issues and experiments in this area are already underway. This is done by such a major specialist as Dr. Zvorykin [113]. If humanity manages to direct the achievements of its mind to serve the goals of progress, and not destruction, then the day after tomorrow we will be able to break out of the sphere of gravity of our planet, as a result of which the volume of our knowledge will expand enormously, and telecontrol will play an important role in this.

Table 17

MK - magnetic compass; KG and GK *, GKsh - gyroscopic compasses tuned to different courses, adjusted from MK; AP — B — autopilot vertical channel; BV - barometric altimeter; RV - radio altimeter: I / C ,. RK% - radio compasses tuned respectively to transmitters Пх нлн / 7г; SPP - blind landing system ILS-; PrSP - receiver of blind landing system; PrG - glnssadny receiver ILS \ QBnj, SVP22 - counters (integrators) of the airway,

tuned to the segments of the path I or II. BOOK

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CONTENT



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Typos

Page Line Printed Should be read
47 Title Closed regulation Closed regulation
gr. 5 according to the scheme, fig. 17 according to the scheme:
54 4 from below Fig. 22 Fig. 22a
55 8 from above Fig. 22a Fig. 226
55 11 from above Fig. 226 Fig. 22c

62 11 from above “Dessa” “Decca”
68 20 from above 2.211.1 2.411.1
92 2 from above Types of energy Types of energy
132 columns 1 3 from above SV-200 GB-200
132 columns 1 “Gainer” “Gayer”
4 from above
141 columns 1 2 on top of the Radishhen Radishey
142 column 1 Shemterling Schmetterling
6 on top
142 column 1 9 on top Shue-Mach Shue-Max
164 3 on top FuKS FuKS-8
167 4 on top DcM DSM
168 5 below Stassburg Stasfurt
168 6 from below Rundfuni * Rundfunk "
190 3 from above (d) (g)
190 9 from above (d) (g)
199 5 from below" Madou "" Maddo "
227 13 from below g (g ~ 8 - distance to the target) g" 8 (g - distance to the target)
240 17 from below Ma <5 Ma> 5
248 13 from above 2 '(' - g) '
260 18 from above \ / “Roma” “Roma”
286 11 from above (PO [9]?) about 6 km (according to [9]?)
302 8 from above Garmon Field Harmon Field
304 5 from below kg, GKu
F, Müller
Table 15
CLASSIFICATION OF TELEVISIONAL AVIATION WEAPONS, ACCORDING TO SECTIONS 1 AND 2 (SEE ALSO TABLE. 10)
Designations 3.523 3.522 3.5 3.523.3 3.524.1 3.524.2 3.525 air defense shells
Fi-SW (Fau-1) A-4 (Fau-2) “Fritz * X '* Hs-293 X-4 Hs-298‟ Schmetterling ″‟ Enzian ″,‟ Wasserfall ″‟ Reintohter ″
1.2 Genus obgecta 1.221.1 Projectile 1.223.2 Long-range missile 1.221.1 Falling bomb 1.222.2 Planning bomb 1.222.2 Fighter missile (air-to-air) 1.222.2 Fighter missile (air-to-air) 1.223.2 Subsonic anti-aircraft missiles 1.223.2 Supersonic anti-aircraft missiles
1.31 Location start of Earth 1.311 1.311 1.313 Earth plane 1.313 1.313 airplane fighter plane 1.313 1.311 Earth (for "Schmetterling" and the plane 1.313)
1.31 place goals 1.311 1.311 Land Land 1.312.1 K Rabl (also Earth) 1.312.1 Vessels (also Earth) 1.313 1.313 Aircraft Aircraft Aircraft 1.313 and compound
1.33 Type of launch 1,334.12 - -22 Catapult 1.334.11 —.21 Free vertical start 1.333.11 Free reset 1.333.11 Free reset 1.313.12 Directional start 1.333.12 Directional start 1.334.12—22 Start from carriage 1.334.12-22 Start from the gun carriage 1.334.11—21 Free vertical start-up 1.334.12—22 Start from the carriage

1.34 Target type 1.341 Area targets 1.341 Area goals 1.342.2 Point targets (moving) 1.342.2 Point targets (moving) 1.342.2 Point targets (moving) 1.342.2 Point targets (moving) • 1.342.2 Spot singing (moving)
1.412 Control coordinate system 1.412.1 Cartesian 1.412.1 Cartesian
1.412.1. Descartes 1.412.2 Polar 1.412.1 Descartes (rotating) 1.412.2 Polar 1.412.2 Polar 1.412.2- Polar 1.412.1 Descartes 1.412.1 Descartes
1.421 Engine type 1.421.16 Jet 1.421.16 Jet 1.421.17 Without engine 1.421 .16 Reactive 1.421.16 Reactive 1.421.16 Reactive 1.421.16 Reactive
1.421.2 Engine type 1.421.241 Direct-flow engine WFD 1.421.242 LRE 1.421.25 Gravity field 1.421.242. LRE 1.421.242 LRE 1.421.243 LRP Powder RD 1.421.242 LRE 1.421.242 LRE 1.421.242 LRE 1.421.243 LRP Powder RD
1.422 Controls 1.422.41 Aerodynamic rudders 1.422.41 - 43 Aerodynamic and gas rudders 1.422.42 Interceptors 1.422. 41 Aerodynamic rudders 1.422.42 Interceptors 1.422.41 Aerodynamic rudders 1.422.41 Aerodynamic rudders (flow stall control) 1.422.41 Aerodynamic rudders 1422.41 -43 Aerodynamic and gas rudders 1.422.41 The rudders in the head part
1.423 Servo type 1.423.1 Pneumatic steering machine 1.423.2 - .1 Electro-hydraulic steering machine 1.423.2 Electromagnetic drive 1.423.2 Electromagnetic drive, DC motor 1.423.2 Electromagnetic drive 1.423.2 Electromagnetic drive 1.423.2 Electromagnetic, electromotor drive unit ? 1.423. 2-1 Electro-hydraulic drive 1.423.2 Electric drive
2.1 Control type 2.11 Stand-alone 2.14 Stand-alone, partially tele-control 2.12 Tele-control 2.12 Tele-control 2.12 Tele-control 2.12 Tele- control 2.12 (2.14) Tele- control (a combination with self-guidance was provided)
2.2 Autonomous control method 2.21 - .224 —.23 Stabilization and program control 2.21 — .23 — .251 Stabilization and program control 2.23 Stabilization relative to the longitudinal axis - - - - - 2.23 Stabilization around the longitudinal axis 2.23 Stabilization around the longitudinal axis
2.3 Method remote control - 2.32 1 directing plane 2.312 2 continuous commands 2.312 2 continuous commands 2.312 2 continuous commands 2.312 2 continuous commands 2.312 2 continuous commands
2.312.1 Type of regulation - Combination with lateral stabilization 2.312.11 Non-closed regulation 2.312.12 Closed-loop control 2.312.11 G Iroscopic switch 2.312.12 Closed-loop control 2.312.12 Closed-loop regulation
2.33 Telecommunication control cable - 2.331.11 The directing plane formed by the radio method 2.331.11 Direct current radio line or wire line 2.332.12-21 High-frequency modulated high frequency oscillations 2.332.12-21 Two-wire direct current communication line 2.331.11 Communication radio line 2.331.11 Radio link
2.4 Methods for determining the target position 2.411.1 Preset target 2.411.1 Preset target 2.412.1 Optical cover 2.412.11-31 Optical and television cover 2.412.11 Optical cover 2.412.11 Optical cover 2.412.11 Optical cover e 2.412.12 or cover after direction finding
2.6 Type of fuse Impact or temporary Impact Impact impact 2.631 Acoustic remote 2.632 Approach 2.63 Remote or approach